DOCUMENT RESUME

ED 329 682 CE 057 082

AUTHOR	Stasz, Cathleen; And Others
TITLE	Teaching and Learning Generic Skills for the Workplace.
INSTITUTION	National Center for Research in Vocational Education, Berkeley, CA.
SPONS AGENCY	Office of Vocational and Adult Education (ED), Washington, DC.
PUB DATE	Dec 90
CONTRACT	V051A80004-90A
NOTE	81p.
AVAILABLE FROM	National Center for Research in Vocational Education, Materials Distribution Service, Horrabin Hall 46, Western Illinois University, Macomb, IL 61455 (order no. MDS-066: $4.50).
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Academic Education; Adjustment (to Environment); *Basic Skills; *Classroom Environment; Classroom Observation Techniques; Cognitive Processes; Curriculum Development; Educational Policy; Educational Research; High Schools; Industry; Job Skills; Participative Decision Making; *Problem Solving; *Self Motivation; Student Centered Curriculum; *Teacher Expectations of Students; Teaching Methods; Technology; *Thinking Skills; Vocational Education
IDENTIFIERS	*Generic Skills

ABSTRACT

Instruction should emphasize generic skills as much as it does occupational or domain-specific skills. Generic skills enable people to: (1) cooperate and communicate for group problem solving; (2) identify and define problems in complex environments; (3) seek, acquire, and synthesize new information; and (4) adapt to changes in the problem-solving environment. To teach these skills, schools must formulate clear educational policies and practices. This is difficult because the term is not clearly defined in the academic literature or in research. This prevents educators from examining several important questions: What generic skills are needed? Are they being taught? Can these skills be taught? and How can schools be structured to develop these skills? A field study collected observational data from four vocational education programs that claim to develop generic skills through their curriculum, and an intensive case study of one class was conducted. The study found that: (1) teachers taught problem-solving skills, often embedded in cooperative working arrangements; (2) project-centered course design and a nontraditional classroom environment supported teaching of dispositions; and (3) student-centered instruction meant that teachers had high expectations for students that extended beyond the classroom. Findings have implications for research on generic skills, for educating diverse student populations, and for reforms advocating the integration of academic and vocational education. (Included in this report are 2 tables, a matrix summarizing selected literature, and a 92-item bibliography.) (NLA)

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TEACHING AND LEARNING GENERIC SKILLS FOR THE WORKPLACE

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Supported by
The Office of Vocational and Adult Education,
U.S. Department of Education

December, 1990

MDS-066

CE057082

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FUNDING INFORMATION

Project Title:	National Center for Research in Vocational Education
Grant Number:	V051A80004-90A
Act under which Funds Administered:	Carl D. Perkins Vocational Education Act P.L. 98-524
Source of Grant:	Office of Vocational and Adult Education U.S. Department of Education Washington, DC 20202
Grantee:	The Regents of the University of California National Center for Research in Vocational Education 1995 University Avenue, Suite 375 Berkeley, CA 94704
Director:	Charles S. Benson
Percent of Total Grant Financed by Federal Money:	100%
Dollar Amount of Federal Funds for Grant:	$5,675,000
Disclaimer:	This publication was prepared pursuant to a grant with the Office of Vocational and Adult Education, U.S. Department of Education. Grantees undertaking such projects under government sponsorship are encouraged to express freely their judgement in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official U.S. Department of Education position or policy.
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PREFACE

This report is part of the National Center for Research in Vocational Education's (NCRVE) continuing effort to understand vocational curriculum and instructional methods. It provides an analysis of the teaching and learning of "generic" workplace skills in several vocational classrooms. We hope this exploratory study will guide future thinking about teaching generic skills and provide a starting point for designing curricula and courses that include these important skills. This study should be of interest to researchers, practitioners, and policymakers in both academic and vocational education who are involved in efforts nationwide to revitalize our secondary schools.

SUMMARY

The latest wave of school reform seeks to reconceptualize schooling for most students. Proposals calling for instructional reform come from many constituencies, with different agendas, but have a similar thrust: instruction should emphasize "generic skills" as much as, or more than, it does occupation-specific or domain-specific knowledge and skills. The assumption is that generic skills will enable people to (1) cooperate and communicate for group problem solving, (2) identify and define problems in complex environments, (3) seek, acquire, and synthesize new information, and (4) adapt to changes and gaps of information in the problem-solving environment. With these skills, workers will be better able to adapt to changing forms of American industry and the occupational structures supporting it.

To teach these skills, schools must formulate clear educational policies and practices. This is difficult under current circumstances, however, because the term is not clearly defined in the academic literature or in research on the workplace, job changes, economic trends, and so on. This prevents educators from examining several important questions: What generic skills are needed? Are they being taught? Can these skills be taught? How can we structure schooling to develop these skills?

This report represents an initial effort to answer these questions. The analysis begins with a conceptual framework for defining generic skills. Observational data from vocational education programs that claim to develop generic skills through their curriculum are analyzed from the perspectives of this framework and cognitive science research on learning and teaching. This analysis aims to understand acquisition of target skills at a level that will inform curriculum development and teacher training. The study sought answers to three questions: What generic skills are being taught? How are they taught? How does the instructional context affect instruction? Findings from this exploratory study have several implications for future research on generic skills, for educating diverse student populations, and for reforms advocating the integration of academic and vocational education.

A CONCEPTUALIZATION OF GENERIC SKILLS

From our analysis of the varied literature, we discerned two basic categories of "generic skills": **basic or enabling skills** include abilities ranging from reading and simple mathematics to "life skills," e.g., reading a schedule or filling out a form; **complex reasoning skills** include skills for defining and solving problems, critical thinking, knowledge acquisition, evaluating problem solutions, etc.

In addition to these skills, which define a person's competency for a task, are the motivational style or **dispositions** that influence task performance, such as the motivation for choosing or doing the task and confidence in one's ability to do it.

There is some debate about the relative importance of these skills and dispositions for employability, productivity, and success. None alone seems sufficient. If people are not motivated for work, their basic or complex skills will be wasted. Conversely, if people bubble over with enthusiasm but lack needed skills, they may be more hindrance than help, though possibly good candidates for education or skill training.

While generic skills and dispositions are all necessary for successful completion of many tasks, complex reasoning skills are among the skills that employers desire most and that school

reformers hope to impart. For this reason we focus on complex reasoning skills—in particular, on generic problem-solving skills identified by a human information processing model of cognition. The concepts presented in this model form a basic vocabulary for analyzing complex reasoning behavior. It identifies several actions in problem solving that are generalizable across domains. These actions, coupled with relevant domain knowledge, enable people to act as intelligent problem solvers. These generic reasoning skills are:

- Recognition of the problem
- Analysis of the problem
- Generation of solution paths
- Evaluation of (partial) solution paths or monitoring as you go
- Repair
- Reflection (after a solution is achieved)

This list of skills provides a starting place for determining whether complex reasoning is taught in vocational classrooms that claim to develop such skills.

WHAT SKILLS ARE TAUGHT?

The analysis reported here is based on an ethnographic case study of a secondary-level interior design class administered by a local Regional Occupational Program (ROP), site visits to technical and nontechnical classrooms where teachers reportedly emphasize domain-general skills, and elite interviews with teachers, a program administrator, and a local employer. We found that these vocational teachers taught several generic problem-solving skills and also stressed development of positive dispositions.

First, teachers taught several specific problem-solving skills embedded in cooperative working arrangements wherein students worked together to solve "authentic" problems. In the case of interior design, students worked for approximately six weeks on a project to design and furnish a six-room Victorian house. In this class (and others), we observed the teaching or use of several generic problem-solving skills. In some cases, the teacher specifically taught or coached the skill; in others, he or she structured the learning environment so that students had an opportunity to use the skills (or at least be exposed to them).

- *Repair skills and learn from errors.* Teachers encouraged students to try different ideas without fear of failure. They believed that mistakes serve to focus a student's efforts: "When they correct mistakes, they will remember what they did."
- *Analyze/specify parts of the problem and generate solution paths.* These skills appeared as we saw students determine goals (e.g., understand the teacher's requirements for completion), set solution criteria (e.g., what should be done to get an "A"), identify constraints and assumptions (both the teacher's and the imaginary client's), identify resources (e.g., special talents of group members), and access relevant domain-specific knowledge (e.g., carpet samples, wallpaper books).
- *Generate solution paths.* Students had to decide whether the entire group should work on each part of a project collectively or whether to assign students to different tasks.
- *Evaluate (partial) solution paths or monitor as you go.* The ill-defined and long-term project required students to organize their goals and manage subtasks to ensure finishing by the deadline.

- *Reflection (after a solution is achieved).* This involves doing a post hoc analysis of a solution and its generation to improve performance next time. The teacher asked the design students to fill out a review sheet in which they were to critique the successes and failures of their project and group and to "figure out why no one is to blame" (for any failures).

These vocational teachers also emphasized student acquisition of generally useful attitudes and work habits. They held that a realistic appreciation of the contingencies present in the world outside of school was as important as (if not *more* important than) learning particular job-related knowledge or skills. The dispositions or attitudes they stressed included:

- *Ability to make decisions.* To complete projects students had to define their own problem, find their own tools for solving the problem, and judge their own solutions.
- *Take responsibility for one's own decisions; devalue appeals to authority.* Teachers consistently deflected requests for information and help when they knew the students could solve a problem themselves.
- *Boldness in decision making.* Teachers recognized that many students are very reluctant to make significant decisions and countered this tendency by encouraging students to be "bold." Stressing boldness in decision making reflected the teachers' concern that many classroom experiences teach students to fear "standing up for themselves."
- *Learning the parameters of workplace situations.* The teachers attempted to help students appreciate the contingencies of the world outside school by making the classroom environment closer to the authentic work environments in which students will eventually find themselves. Teachers did not shy away from exposing students to some of the harder realities of the workplace. For example, if students complained about deadlines they were often met with the response that in the workplace a missed deadline has serious consequences.
- *Cooperative skills.* Several factors conspired to make cooperative skills important in the classrooms. Group projects required students to work together. Cooperation was explicitly sanctioned and discussed, using the term "consensus process." In this process, students made decisions (e.g., selecting fabric) by offering their choices and at least one reason to justify their selection (the rationale). Other students were required to respond to that choice and debate it in terms of the offered rationale. Cooperation also resulted from the teacher's insistence on making the students use the environment to solve their problems, rather than relying on the teacher's authority and expertise.

Teachers did not administer tests to assess student acquisition of these skills and dispositions, but evaluated students on a more individual basis. In interior design, for example, student grades depended less on the "excellence" of a project solution than on the teacher's estimate of how far the student had come during the semester.

HOW THE CLASSROOM ENVIRONMENTS SUPPORTED LEARNING

For purposes of discussion, we divide the classroom environments into three categories: curriculum and classroom, teacher policies, and teaching techniques.

Curriculum and Classroom Features

Two features of the curriculum stood out: project-based activities and freedom in organizing projects. Teachers designed project-based courses in which students could make many choices in an environment free from typical classroom rules. The project set the stage for fostering and supporting a variety of generic problem-solving skills and dispositions. Projects enhanced the "authenticity" of the learning experience, particularly where they were structured to mimic, as much as possible, an actual working environment.

The way the projects were organized also contributed to student learning. In these classrooms, we observed a high degree of student choice at many levels: choice of projects, no intermediate milestones, student work was self-paced, teachers resisted intervention, and students performed different tasks and learned different skills.

Teacher Policies

The teachers had several broad rules of thumb or policies that seem to govern how they informed and interacted with students.

Teacher and student on an "equal" footing. Many observations suggested that teachers strove to interact with students "on their level" or perhaps to elevate students to the teacher's level. This was most easily seen in the casual friendliness and respectfulness of teacher-student interactions. The existence of this common level was clearly understood explicitly by the teachers and perhaps more implicitly by the students.

Master-apprentice relationship more than student-teacher. Broadly, the kind of relationship we observed arising between student and teacher was neither the usual student-teacher relationship nor a strictly collegial one. Rather, in some respects, it resembled the roles of master and apprentice. The teacher was regarded as the expert or "model" practitioner of the craft and also possessed a greater associated factual knowledge and skill. On the other hand, the student had a limited knowledge of facts and skill but was increasing both continually. Although the teachers were competent lecturers, they placed little emphasis on this way of imparting information. Rather, one-on-one tutoring or master-apprentice interactions were the main methods by which teachers distributed information and shaped student progress.

"Adult" learning model. Much of the teachers' behavior can be accounted for by their explicit view that students are mature, reasonably experienced, and motivated to learn. We observed several ways in which this model worked well for the students: it promoted an egalitarian atmosphere in class, it permitted greater time-on-task in projects, and it enabled teachers to focus more of their teaching efforts on "micro-apprenticeships" than lectures.

Class projects as business; accountability. Throughout project work, the teachers continually shaped students' learning and performance by relating aspects of the project to the workplace. Projects were initially motivated by their relationship to external factors and, in many cases, the activities students were engaged in during their project simulated real working tasks.

Techniques

Teachers employed specific teaching techniques to implement their policies. In particular, they employed several techniques to solve some of the problems that can arise in a project-centered classroom where students are given considerable freedom.

Techniques for encouraging boldness and independence—a "fail-soft" environment. Teachers recognized that students would not be willing to make bold, independent

decisions in an environment that harshly penalizes the failures that inevitably result. Several teacher techniques insured that students did not regard failure as undesirable.

- *Attempts at creative solutions regarded as intrinsically desirable.* The interior design teacher made it very clear to her students that the act of trying unusual design combinations would be rewarded regardless of their quality. Students with "objectively" poor projects could get high grades if they had shown attempts at creative thinking and consistent attention to the task at hand.
- *Refraining from correcting errors.* Teachers often did not correct student errors but pursued more constructive approaches—they might provide alternatives to the students' proposals but would "force" students to make the final judgement.
- *Negative feedback without negative affect.* Two teachers we observed were exceptionally gifted in being able to communicate criticism or negative information without threatening students. The students appeared to understand that criticism did not mean a loss of respect or caring.
- *Constructive use of failures.* Both teachers were able to turn failed attempts at problem solution into positive learning experiences, by encouraging students' attempts to generate many solution paths in confronting a problem.

Techniques for dealing with students who are not proceeding in unison. One of the major challenges facing the teachers was the problem of dealing with students who are often simultaneously engaging in very different tasks. The teachers appeared to use several tools or tactics:

- *Motivation and responsibility.* Teachers motivated students by holding high expectations, including student responsibility for their own work and behavior. Motivated students generally require relatively little minute-to-minute monitoring.
- *Grading.* As in most classes, final grades appeared to be an important tool in keeping students on task.
- *Group management skills.* Teachers had excellent monitoring and diagnosis abilities. They could rapidly scan a class and determine when a student's mistake had gone too far. Then the teachers would intervene, often orchestrating the encounter at a distance.
- *Apprenticeship and micro-teaching techniques.* Teachers accepted the need to frequently repeat information to students, and they turned that burden into a benefit by delegating that authority to students who had already been tutored.

Techniques for dealing with students who are solving ill-defined problems. Because students were not used to dealing with ill-defined problems, we saw many instances of floundering and low productivity in early stages of the project. For the most part, teachers let this happen. The interior design teacher felt that giving students more detailed project requirements would threaten their creative reasoning and interfere with boldness in decision making. She was willing to let students flounder early in the project in return for interesting ideas later.

EXTERNAL FACTORS THAT SHAPED THE LEARNING ENVIRONMENT

Many different kinds of factors can influence what goes on in schools. While we can't often link these characteristics directly to student learning or persistence in school, we know

that they can either enable or constrain classroom teaching and learning. From our observations and interviews we formed a picture of the factors that affect instruction in the interior design class. Our major conclusion is that two key factors shaped instruction: teacher autonomy and the teacher's educational philosophy. While school and organizational policies highly affect the former, they have little direct impact on the attitudes that the teacher brings to the classroom.

Research points to three enabling conditions that appear to promote high-quality teaching and learning to the degree that they exist in schools: access to knowledge, press for achievement, and professional teaching conditions. Aspects of the school context work both for and against these conditions. In the interior design class we observed, access to knowledge was promoted because the teacher had the resources to purchase necessary material to support the house design project and because students had opportunities to learn by working in a local retail store.

Press for achievement—institutional pressures that the school exerts to get students to work hard and achieve—was not stressed for vocational students by the school administration: the academic curriculum takes precedence over the vocational, and college enrollment figures are used to measure school success. The vocational teachers, however, fostered press for achievement by having high expectations for students and valuing growth in the quality of their work.

The interior design teacher faced a mix of professional teaching conditions that can either empower or constrain teachers as they attempt to create and implement instructional programs. On the positive side, she had little paperwork or bureaucratic requirements, a very supportive administrator, and autonomy in making classroom curriculum and instructional decisions. On the negative side, as a vocational teacher for the ROP she was outside the broader school culture. This isolated her from teaching colleagues, collaborative staff activities, and school decision making.

IMPLICATIONS FOR FUTURE RESEARCH AND PRACTICE

From this small sample of classrooms and the exploratory nature of this study we cannot draw strong conclusions or policy implications for teaching and learning generic skills. But our findings do suggest several directions for future research on teaching generic skills, educating diverse student populations, and integrating academic and vocational education.

Our results indicate that an emphasis on training generic skills alone is unlikely to be successful without the parallel development of an adaptive motivational style. Much more research is needed on the dispositions, attitudes, and motivations that will enable students to apply their skills in school and workplace settings. An approach that combines theory and findings from the cognitive science and social cognition literatures seems a promising way to study the interplay of generic skills and dispositions.

Teacher autonomy and teaching philosophy stand out as important conditions for teaching generic skills, but such conditions differ according to the teacher's school administration or personal characteristics. Research needs to examine these and other context factors more closely for both vocational and academic teachers. Since the vocational and academic can represent different subcultures in many comprehensive high schools, school context conditions are likely to affect different teachers in different ways.

One interesting quality of the instructional practice in these vocational classrooms was its appropriateness for teaching a diverse group of students. Since trends show increasing

diversity of student populations, practices suited to diversity may be in even greater demand. In particular, the apprenticeship model used by these vocational teachers seems promising. Research from the perspective of traditional apprenticeships, in combination with new models of "cognitive apprenticeship," might explore several questions, including: How can apprenticeships be structured to serve diverse students in large classroom settings? Can apprenticeship techniques be applied to teaching domain-specific knowledge and skills and *generic* skills, in addition to complex physical processes and skills?

Our study also suggests that approaches for teaching generic skills can be applied to achieve integration of vocational and academic curricula. Educational reformers from both the academic and vocational communities see a need to improve students' abilities to reason, think, and solve problems. To explore the viability of teaching generic skills as a vehicle for integration, future work should study both vocational and academic classrooms. We need to verify that some instructional practices found in these vocational classes (e.g., solving authentic problems cooperatively with a team of students, micro-apprenticeship) can transfer to academic subjects or content areas where the analogy between class work and actual working environments is not as strong. In addition, it may be that teachers need actual working experience to prepare them to impart the dispositions and attitudes that complement a particular "culture of practice."

In general, we recommend that future research continue to identify the acquisition and teaching of target skills and dispositions at a level of analysis that will inform curriculum development, teacher training, and teaching practices. Broad descriptions of needed workplace skills are not adequate for teachers, who have the ultimate responsibility for carrying out any curricular reform.

ACKNOWLEDGMENTS

This study would not have been possible without the cooperation of the teachers and students who allowed the research team into their classrooms. We thank them and their administrators, who fully supported our efforts.

Several other individuals provided assistance. Harry Silberman, Professor of Education at UCLA, helped us identify potential sites early on in our study. Joyce Peterson, RAND communications analyst, helped us clarify our ideas and structure the initial draft of this report. Robert MacCoun and Thomas Glennan of RAND provided thorough and thoughtful technical reviews that challenged our thinking and greatly improved this document. Jeannie Oakes made helpful comments on our analysis of school context factors. Linda Weiss and Karleene Schindler helped prepare the manuscript for publication.

We thank all these individuals for their assistance, but retain full responsibility for the analysis and conclusions reported here.

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I. INTRODUCTION

Many constituencies are insisting that the time has come to reconceptualize schooling for most students. Major changes in the economy and widespread dissatisfaction with the performance of our schools have led to calls for instructional reform from educators, policymakers, researchers, employers, and social critics. Although their agendas may differ, many of their proposals have the same thrust: Instruction should emphasize "generic skills" as much as, or more than, it does occupation-specific or domain-specific skills.

Teaching generic skills is viewed as one way to address an increasing labor market problem of demand and supply. The changing nature of the workplace demands workers with certain kinds of aptitudes and abilities, but the educational system has not been producing them. Generic skills will enable people to

- Cooperate and communicate for group/social problem solving.
- Identify and define (or structure) problems in complex environments.
- Seek, acquire, and synthesize new information.
- Adapt to changes and gaps of information in the problem-solving environment.

This new emphasis on generic skills assumes that the people who have them can adapt to the changing forms of American industry and the occupational structures supporting it.

To better prepare all students for the world of work, schools must formulate clear educational policies and practices for teaching these skills. However, that is easier said than done under current circumstances. It is true that generic skills are much discussed in a range of academic disciplines[1] and in research on industries, the workplace, schools, job changes, training, and economic trends. It is also true, however, that the term is still not clearly defined. This prevents educators from systematically examining several important questions: What generic skills are needed? Can these skills be taught? Are they being taught? How can we structure schooling to develop these skills?

PURPOSE AND NATURE OF THE STUDY

In 1989, we launched a study to begin addressing these questions. Our strategy was (a) to construct a conceptual framework for defining generic skills; (b) to further develop that framework, based on cognitive science theory, for studying one category of generic skills—complex reasoning; (c) to observe and analyze programs that claimed to develop generic skills through their curriculum; and (d) to explore the implications of our findings for future research and curriculum development. This report presents the study's results.

Much of the discussion of generic skills comes from four sources: research on changes in the nature and structure of work; research on schooling; research on generalizable skills and skills that distinguish expert from novice performance; and research on domain-independent reasoning.[2] In this varied literature, we discerned two basic categories of "generic skills":

[1]These include sociology, cognitive science, economics, organizational development, anthropology, and industrial psychology.

[2]We discuss this literature in Sec. II.

- *Basic or enabling skills.* These include a range of abilities, from reading and simple mathematics to "life skills," e.g., reading a schedule or filling out a form.
- *Complex reasoning skills.* These include skills for defining and solving problems, critical thinking, knowledge acquisition, evaluating problem solutions, etc.

In addition to these skills, which define a person's competency for a task, are the motivational style or *dispositions* that influence task performance, e.g., motivation for choosing or doing the task, confidence in one's ability to do it.

The literature contains some debate about the relative importance of these skills and motivations for employability, productivity, and success. There is no clear hierarchy or taxonomy. Some argue that if people are not motivated for work, their basic or complex skills will be wasted. Conversely, others argue, if people are charged with enthusiasm but completely unskilled, they may be more hindrance than help, though possibly good candidates for education or skill training. A third argument is that workers who have *only* enabling skills and positive work-related dispositions will have limited roles in the workplace. In this argument, complex reasoning skills are the essential condition for success.

While generic skills and dispositions are all necessary for successful completion of many tasks, complex reasoning skills are among the abilities that employers most often identify as critical and that school reformers emphasize most. Further, cognitive science research on complex reasoning and problem solving (in several academic subjects) provides a formalization for precisely defining these skills and suggesting ways to teach them. Other literature provides models for understanding how motivations can affect skill acquisition and use, but "motivation" is less well defined, and there is no conceptual framework for considering how it might be taught. As for basic or enabling skills, while the lack of them is potentially disabling, there are many theories, constructs, and curricula for teaching them. However, hardly anyone would argue that basic skills alone constitute the essential spark for effective and prolonged performance in the labor market.

We began our study with the belief that complex reasoning skills were the most vital, were the most readily "teachable," and would be the most strongly emphasized in the high-school-level classrooms we observed. However, the results of our field work indicate that teachers who have experience in the workplace emphasize dispositions—and seek to cultivate them—as much as (if not more than) they stress complex reasoning skills.

To carry out their instructional goals, the teachers we observed employed several nontraditional techniques and methods. Overall, they minimized lecturing and didactic instruction in favor of "micro-apprenticeships," one-to-one tutoring, and project-centered courses wherein students worked together to solve "authentic" problems. The instructional context was one in which teachers had the autonomy to balance the teaching of domain-specific knowledge and skill requirements with generic skills as well as the freedom to employ nontraditional instructional and evaluative methods.

ORGANIZATION OF THE REPORT

Section II reviews the literature and presents our conceptualization of generic skills. We also illustrate how this perspective can be applied to problem solving in several vocations. To better understand generic skills teaching in practice, we studied several programs that claimed to emphasize the teaching of generic skills in their curriculum. We augment our classroom analysis with an examination of the broader instructional context in which the course was

taught. The field study is discussed in Sec. III. Section IV presents the results of our fieldwork, which focused on several questions: What generic skills are being taught? How are they taught? What contextual attributes—teaching methods, school philosophy, student population—contribute to their success? Finally, in Sec. V we examine what the answers to these questions imply for teaching generic skills, for educating diverse student populations, and for reforms advocating the integration of academic and vocational education. An appendix summarizes several selected studies from the literature.

II. BACKGROUND AND CONCEPTUAL FRAMEWORK

In this section we first review briefly the literature to give some perspective on the breadth and nature of the discussion about "generic skills." Much of this discussion comes from four sources: research on the changes in the nature and structure of work, research on schooling, research on generalizable skills and skills that distinguish expert (as opposed to novice) performance, and research on domain-independent reasoning. (A summary of several selected studies is also presented in the Appendix.) We then present a broad approach for considering skilled behavior and a conceptual framework for studying one category of generic skills—complex reasoning skills. Finally, we describe how this conceptualization of generic skills might apply to understanding the general aspects of problem solving that occur across different vocations.

CURRENT VIEWS ABOUT GENERIC SKILLS

Changes in the Nature and Structure of Work

Studies of changes in work, and reports in the popular press, note the gradual shift of capital and labor out of smokestack industries and into high-technology and service industries. This broad shift is marked by technological advances that affect workers and the workplace across many industries. Research and experience highlight several impacts that imply new skill demands. For example:

- Organizational changes occur, with more emphasis placed on flexibility, autonomy, and interaction of smaller working units (Office of Technology Assessment, 1988).
- Problem solving and retraining are expected to take place at much lower levels in such decentralized organizations (Noyelle, 1987; Bailey and Noyelle, 1988; Stasz, Bikson, and Shapiro, 1986).
- New technologies change rapidly, and adapting to those changes requires different situation/tool-specific knowledge and skills (Office of Technology Assessment, 1988; Noyelle, 1987).
- Changes due to automation and the introduction of computers have in many cases widened the breadth of skills required for jobs (Bikson and Eveland, 1986).

These and other workplace changes suggest several skill needs. Changing organizational and work group structures, for example, may require the types of skills that make collaborative arrangements work: a high level of skill and ability among group members, teamwork experience, participative decision making, and efficient intragroup communications (McGrath, 1984; McGrath and Altman, 1966). Other changes may necessitate fewer technology or domain-specific skills and broader workplace skills, including those that support new styles of operation: communication, cooperation, and the ability to recognize, define, and adapt to the problems and conflicts inherent in human interaction (Deutsch, 1987). Workers dealing with computers that take over processing functions are left with diagnostic and problem-solving functions (Noyelle, 1987). These functions can range from the secretary trying to format a footnote with a new text-editing package to the technician trying to diagnose and repair a

nonobservable electronic component. That is, certain new technologies call for skills *different in kind*: skills of the head rather than the hand, of the logician rather than the craftsman (Attewell, 1987).

The "generic" skills identified by research find broad corroboration among employers in the job marketplace. As a closing example, Brown (1988) reports that when employers are asked what things are important in decisions to hire, fire, or promote employees, they often emphasize attributes beyond basic or job-specific skills. At a meeting with businessmen, Brown asked about the attributes of the ideal employee and found the following:

> The first word spoken was creativity. Then someone mentioned flexibility. Then came problem solving and skill in dealing with people, adaptability, innovation, and a capacity to change. Several people stressed responsibility, teamwork, loyalty, and good work habits and attitudes. Eventually, someone mentioned basic skills.

Research on Schooling for Nonschool Activities

In the educational community, the notion of "generic" skills has received the most attention from school reformers, who seek a reconceptualization of schooling. There is a growing concern for the mismatch between the curricula and pedagogy of our schools and the knowledge requirements of nonschool settings. Reformers are calling for schools that will produce more creative, inventive, flexible, proactive, and problem-solving students (e.g., Office of Technology Assessment, 1988; Berryman, 1988; and Oakes, 1986). However, studies of both vocational and nonvocational schools suggest that most educational institutions do not explicitly teach these skills (Berryman, 1988; Powell, Farrar, and Cohen, 1985; Stern et al., 1985).

Resnick (1987b), for example, notes four fundamental contrasts between in-school and out-of-school mental activity that raise profound questions about the utility and effectiveness of schooling for all nonschool activity, including work. First, while the dominant form of school learning and performance is individual, much activity outside school is socially shared. Second, schools place a premium on "pure thought" activities without the benefit of tools (for example, calculators and books during test taking), whereas most mental activities outside school are shaped by and dependent upon use of available tools. Third, schools tend to emphasize abstract symbol manipulation, whereas work and other activities emphasize reasoning and actions connected with physical objects and events. Finally, while schools aim to teach general, widely usable skills and theoretical principles, success outside school depends on the development of situation-specific forms of competencies. These points suggest the need for skills similar to those identified in workplace research: more emphasis on the development of cooperative learning or group skills; less emphasis on learning abstract, domain-specific theories and facts and more on using this knowledge to reason about real-life problems; and more attention to how tools shape cognition in specific situations.

Research on Generalizable Skills and Expertise

Research in vocational education and cognitive science adds to the previous views of "generic" skills. Among vocational educators, Greenan's work on generalizable skills stands out (e.g., Greenan, 1983, 1984, 1987; Greenan and Browning, 1987). Greenan's (1983) analysis of "generalizable" skills produced a compendium of 115 different subskills or items, grouped into four different types: mathematics, communication skills, interpersonal skills, and reasoning skills. Within these classes, some items are very broad and cover a wide range of different

skills (e.g., the ability to solve problems involving time, weight, distance, and volume). Greenan has also developed assessment techniques in the form of student self-ratings, teacher ratings, and a performance criterion for each skill area, and has compiled directories of available instructional resources that are potentially useful for teaching generalizable skills. However, his program of research has not yet studied the teaching of these skills or developed instructional programs.

Other notions about generic skills come from recent research in cognitive science on what makes a person an "expert" in a field, and how experts transfer school-based knowledge to nonschool settings. This research shows that cognitive and metacognitive strategies[1] and processes are more central to expertise than low-level subskills or abstract conceptual and factual knowledge (e.g., Lave, 1988; Scribner, 1984; Collins, Brown, and Newman, 1989). An expert technician, for example, has strategies for dealing with a problem (e.g., break it down into smaller parts) and can reflect on his own progress (e.g., evaluate whether or not the current solution is a good one). These skills are more important than low-level skills (e.g., being able to read the manual) or abstract knowledge (e.g., understanding how electricity flows through circuits).

Other research examines ways to teach students to use the kinds of processes employed by experts to handle complex tasks and also to apply them in a variety of contexts (e.g., Collins, Brown, and Newman, 1989; Lave, 1977). This requires teaching techniques that externalize cognitive processes that are usually carried out internally, so that students can observe, enact, and practice them with help from the teacher and other students. Modeling, for example, involves showing an expert carrying out a task while students observe and thereby build a conceptual model of the processes required to accomplish the task (Collins, Brown, and Newman, 1989; Wood and Bandura, 1989). Thus, a teacher might model the reading process by reading aloud in one voice, then verbalizing her thought processes (e.g., what the author means, what will happen next) in another voice (Collins and Stevens, 1982). Coaching is another technique. Here, the teacher observes a student while he or she carries out a task and offers hints, feedback, reminders, or new tasks aimed at bringing the student's performance closer to expected performance. In reading, a teacher in the role of coach might choose texts with increasing difficulty, have students write summaries of the texts, and have other students offer suggestions to the class on how a summary might be improved (Collins, Brown, and Newman, 1989).

Research on Domain-Independent Reasoning

While studies of expertise reveal skill needs and how skills are employed to solve problems in a particular domain, other research (e.g., Nisbett et al., 1987) examines domain-independent reasoning: Do people use abstract rules to think about everyday life events and, if so, can these rules be taught? This line of research counters claims that people possess domain-specific knowledge that is not readily applied to other domains (e.g., Thorndike, 1906; Chi, Glaser, and Farr, 1988), or that their possession and application of knowledge depends on cognitive development and cannot be taught (e.g., Brainerd, 1978). Evidence for domain-independent reasoning is important for any conception of generic skills, since the notion that

[1]In the research literature, "metacognition" refers to several categories of intellectual behavior, including knowledge about your own thought processes, control or self-regulation (e.g., how well you keep track of what you're doing when solving problems), and beliefs and intuitions (cf. Schoenfeld, 1987).

skills can be applied across domains is a key assumption underlying the view that generic skills should be taught and learned.

Nisbett et al. (1987) report on several studies that show use of abstract rules and increase in rule use after training. People can, for example, use statistical rules that are derivable from the law of large numbers to reason about problems in a wide range of tasks and domains. Furthermore, their reasoning improves with training that shows how to use the law of large numbers to solve a number of problems.

Two studies of graduate students by Lehman, Lempert, and Nisbett (1988) demonstrate the trainability of reasoning skills that correspond to the program of study. Beginning students in law, chemistry, psychology, and medicine had equivalent inferential skills for statistical reasoning about problems with both scientific and everyday life content, methodological problems dealing with different types of confounded variables, and several other problem types. After two years of study, psychology and medicine students showed significant increases over law and chemistry students in their ability to use statistical and confounded variable rules in both scientific and everyday life problems. This difference in performance reflects differences in the nature of these disciplines. Psychology and medicine are probabilistic sciences and must deal with all kinds of causal patterns involving necessity and sufficiency. Thus, students learn and practice inferential reasoning and rules for dealing with uncertainty or the conditional. Law students show improvement only in problems dealing with the conditional, presumably because they are taught about contractual relations. Chemistry students do not improve on these types of problems because their field deals primarily with necessary and deterministic causes rather than probabilistic ones. This research suggests that reasoning can be improved by training and that rules applied to reasoning in a discipline can generalize to reasoning in analogous everyday life situations.

In sum, although the popular and scientific literatures are replete with lists of domain-independent skills, the term "generic skills" is poorly defined. Terms abound in the literature and seem to include disparate types or levels of skill as well: for example, is "recognizing that a problem exists" (Sternberg, 1985) a skill in the same way that "accurate, fast arithmetic calculation" (Greenan, 1984), "self-management" (Chipman, 1988), or "creative thinking" (Greenan, 1984) are skills?

Drawing from the generic skills literature and cognitive science research, we conceive two broad categories of generic skills: basic or enabling skills and complex reasoning skills. In addition, we assume that individuals possess dispositions and motivational styles, distinct from their skills, that influence effective use of skills. We elaborate on this conceptualization below.

A CONCEPTUALIZATION OF GENERIC SKILLS

Whether faced with school-related, work-related, or everyday life tasks, individuals bring a constellation of knowledge, skills, and motivations to bear in accomplishing them. Knowledge, skills, and motivations interact with each other and with the task in complex ways to produce degrees of success or failure. While skills define a person's *competence* or ability to do a task, motivations influence task *performance*.

To provide a starting point for analyzing generic skills in this exploratory study, we focus on competence factors and simplify them into two broad categories:

- *Basic or enabling skills* include such abilities as reading, doing simple mathematics, and "life skills," such as reading a schedule, writing a check, or filling out an application.

These skills are often used by people in the service of more complex tasks involving higher skill levels.

- Many tasks require the use of *complex reasoning skills*. Some tasks require formal reasoning: the problem to be solved specifies all premises or given information in advance (e.g., problems in logic, geometric analogies, series completion). Other tasks require informal or everyday reasoning: premises are not completely supplied for the problem, and everyday thinking activities must be invoked (e.g., planning, making commitments, evaluating arguments, choosing options; see Galotti (1989) for a detailed discussion).

These generic skills can be applied in a variety of domains or vocations and in combination with the domain-specific knowledge and skills that define competence in a particular area. In following sections we discuss this interplay further and elaborate on the use of complex reasoning skills in a specific problem-solving activity.

In addition to their specific or generic skills, individuals bring to a task dispositions or attitudes that can play an important role in how any skills are acquired and used (Dweck, 1986). In the context of school and learning, these psychological factors influence a person's motivation to respond in either adaptive or maladaptive ways to a particular task. Dweck and Leggett (1988), for example, review a body of research that identifies two major patterns of response in achievement-oriented settings: the maladaptive or "helpless" response and the more adaptive "mastery-oriented" response. While the helpless pattern is characterized by an avoidance of challenge and a deterioration of performance in the face of obstacles, the mastery-oriented pattern involves the seeking of challenging tasks and persistence under failure. Research with children shows that these behavior patterns are unrelated to actual ability: bright, skilled individuals can exhibit a maladaptive pattern. Children of equal ability can show marked performance differences in response to challenge, because they are pursuing different goals (Dweck and Elliott, 1983) or because they have different beliefs about whether intelligence is a fixed or a malleable quality (Dweck and Leggett, 1988). We can think of these responses as "motivational styles" or dispositions toward approaching achievement situations in a certain way.[2]

Several simplifications are implied in this conceptualization. First, it implies a discrete separation of complex and basic skills. In fact, a "basic" skill such as reading is cognitively complex. It involves such "low-level" processes[3] as decoding letters or recognizing words, but it also requires certain "high-level" strategic skills necessary for comprehension, such as formulating questions based on the text, summarizing the text, making predictions, and clarifying difficulties with the text (see Palinscar and Brown, 1984). Similarly, doing mathematics requires mastery of the basic facts of addition and subtraction as well as more complex problem-solving strategies and heuristics. Although we acknowledge that basic literacy skills

[2]Throughout the remainder of this report we use the terms "motivation," "dispositions," and "motivational style" to refer to psychological factors that can influence task performance. We acknowledge that these terms have distinct definitions in the literature, but the distinctions go beyond the level of analysis required for the purposes of this exploratory study.

[3]We use the terms "low level" and "high level" with great caution. The meaning and implication of these terms, as well as the terms "lower order" or "higher order" skills, rest on an assumption that there is a sequence from lower-level activities that don't require much independent thinking to higher-level ones that do. As Resnick (1987a) and others point out, cognitive research provides a fundamental challenge to this assumption and the educational practices it supports. Given the controversy, we want to be explicit that our terms do *not* assume a sequence of skill development or a continuum from "simple" to "complex" skill. This is separate from current views of the *execution* of skills, where there is a hierarchy of control of actions, such as hierarchical goal-setting knowledge. This is the distinction we wish to make.

can be cognitively complex, we use this category to distinguish the minimum skills a person brings to a problem or a task from the knowledge and skills required to *make use of* concepts, facts, and procedures as necessary for those problems or tasks. It is these latter kinds of complex reasoning skills, or strategic knowledge, that characterizes expertise in a domain (e.g., Collins, Brown, and Newman, 1989).

Second, dispositions and motivational style can affect skill use. Resnick (1987a), for example, points out that students who do not have dispositions or "habits of thought" that lead them to engage in higher-order thinking may not learn complex reasoning skills even if they are exposed to them. Perhaps more importantly, such students will not refine their reasoning abilities, or know when to use them, if they are not disposed to exercise them.[4]

While this conceptualization does not specify "levels" of skill or delineate precise relationships between skills and motivational factors, it does provide a useful starting place for thinking about "generic" skills, their relative importance, and their teachability. Clearly, if an individual does not have the dispositions or motivations to work, the basic or complex skills he or she possesses matter little. That is, the person may have the competence but will not display skilled behavior because his or her motivational style does not lead to effective performance. Conversely, if a person is completely unskilled but bubbling over with positive work-related dispositions, he or she may be more of a hindrance than a help, but possibly a good candidate for education or skill training. Indeed, people without what we label as basic or enabling skills in our culture are quite capable of performing complex tasks. However, we argue that workers with only enabling skills and an adaptive motivational style, although perhaps readily trainable, will have limited roles in the workplace. Complex reasoning skills, however, appear to be key to adapting to changes in the workplace, and they also encompass many of the attributes that employers desire and school reformers hope to impart.

While our initial framework includes both basic or enabling skills and complex reasoning skills as "generic" and recognizes the key role that motivational styles and dispositions play in skilled behavior, the remainder of this section focuses on a conceptualization of complex reasoning skills. We elaborate on and more precisely define these skills from the perspective of cognitive science research. This perspective provides a needed formalization of these key skills, but it has much less to say about the role of disposition or motivational style. We do not elaborate further on basic or enabling skills because, as stated above, this study is less concerned with the minimum skills a person brings to a problem or task than with the skills he or she possesses for *making use of* concepts, facts, procedures, and so on. What follows, then, is a partial elucidation of a broader conceptual framework that provides a starting point for examining the teaching and learning of generic skills in the classroom.

Complex Reasoning and the Information Processing Metaphor

A metaphor that has proved fruitful for the cognitive scientist's attempts to understand human behavior is that certain aspects of human cognition and problem solving can be compared to other information processing devices, namely computers (Newell and Simon, 1972; Simon, 1979). Both take in information from the environment, store it, manipulate it in the form of some kind of symbol system, and take action on or give output to the environment. Much of what people do can be thought of as "decision making" or simple to complex "problem

[4]Several psychological models distinguish motivation and skill or ability as separate, but interacting, antecedents of cognitive performance—e.g., Beach and Mitchell's (1978) contingency model; Chaiken and Stangor's (1987) systematic processing model; Petty and Cacioppo's (1984, 1986) elaboration likelihood model. It is beyond the scope of the present study to examine them in detail with respect to generic skills.

solving." People act in response to questions like: How do I get to the airport by 8:30? How do I summarize these three reports? Why isn't my production team communicating? How can we improve productivity? While this metaphor does not easily take into account such important performance factors as disposition or motivational style, it does provide an organizing framework for examining human problem solving across tasks and building process models of cognitions. This metaphor is called the human information processing (HIP) model or theoretical framework. This framework can explicitly define some generic skills and can suggest ways to design curricula and pedagogical practices aimed at teaching them.

As mentioned earlier, central to the application of the HIP framework to generic skills is the view that many human activities, both in the workplace and in life, exemplify problem solving. This includes everything from deciding on what kind of rivets to use to repair an airframe to planning a menu. An important aspect of most problem-solving situations is the notion of "search." Search is the activity examining or "navigating" through all the possible actions (and outcomes of those actions) that can be taken in a situation.

In the language of HIP, outcomes are "states" to be attained. We refer to the set of all possible states as a "state space" or the space of all possible intermediate states that one might visit in the course of "search." Problem solving takes place as one tries to apply known actions or "operators" to the start state. Every time an operator is applied to a state it creates a new state. If the new state that is reached is the same as the state one wants to get to (the "goal state"), then the problem is solved. As operators are applied and intermediate states are reached, a trail or "path" is created. The total path consists of states (stepping stones) and operators that move a problem solver from state to state (steps). The constraints on operators are the rules that say whether it is "legal" to apply a given operator at a given state. So, problem solving is the search for a "solution path" of operators and their corresponding states from the beginning of a problem (the start state) to the solution (the goal state).[5]

Although the concepts of start state, goal state, solution path, operator, and constraints are very abstract and general, they are not a complete characterization of what the HIP framework sees as common to different problem-solving domains. (For example, there are also search strategies that are generalizable across domains.) However, these concepts are the basic vocabulary that cognitive scientists use to analyze complex reasoning behavior. In doing so, they have discovered that many behaviors that appear different on the surface exhibit common patterns when seen from the perspective implicit in the HIP vocabulary (Newell, 1981). These common activities are at the heart of this view of generic complex reasoning skills.

To illustrate generic problem-solving activities from the HIP perspective, let us walk through one solution to a common problem: getting to the airport on time to catch a flight. Following this example, we shall discuss each component in more detail.[6]

GET ME TO THE AIRPORT ON TIME

> My flight to Boston takes off at 8:00 A.M. tomorrow. I don't live close to the airport, and I suspect that getting to the airport for a flight that leaves at 8:00 puts me in rush-hour traffic. This is an unpredictable situation that calls for some planning. (*Recognition of the problem.*)

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[5]While other approaches can be used to study complex reasoning (e.g., the componential approach or the rules/heuristics approach), a search approach, in combination with a mental models approach, seems the most extendable to everyday reasoning and seems to deal more directly with important dispositions and attitudes (e.g., to avoid impulsivity by searching as systematically and thoroughly as possible). See Galotti (1989) for a comprehensive review and comparison.

[6]While this example will be used to demonstrate many of the components of a human information processing approach to reasoning, it does not do justice to a variety of important concepts. Several introductory texts present other aspects of human information processing (cf. Anderson, 1985; Newell and Simon, 1972; Simon, 1979).

The goal is clear: I've got to be on that plane when it takes off at 8:00. Where I am now is less clear. Have I done my laundry recently enough or must I do a load tonight so I have clean clothes for the trip? Do I know when the shuttles run or how much it costs to park at the airport? Is it going to snow tomorrow and maybe increase the chance that traffic will be knotted? What horror stories come to mind from friends who have been in similar situations? (*Analysis of the problem.*)

Okay, having collected some information that is relevant to my decision (e.g., that the weather is not looking good, that the only early shuttle gets me to the airport at 6:30 A.M., that parking is cheap), I start making plans. Given that I want to be on the plane, I should work backwards from 8:00 A.M. and get to the airport at 7:30. That means leaving my place by 6:45, no, make that 6:30 to keep some margin for error, which means getting up at 5:30. On the drive the next morning, I find that the light snow falling has snarled traffic along the most direct route. I turn on the radio to listen to the traffic report and start looking for alternate routes. I might have to get off the parkway, double back, and retrace some of my route to get across the river, but it will probably be worth it in time savings. I'll try my planned alternate route. (*Generation of solution paths and evaluation of solution paths.*)

Bad idea. This highway looks like a parking lot. I forgot that Route 16 is being resurfaced and has a lane closed! I should have thought about that earlier. Next time I'll be sure to check with the automobile association the day before about conditions. Here I sit, the clock is ticking, and I've already used up the extra time I allowed myself. What other routes have I heard about? How about taking the reportedly less crowded route through the east end of town? It couldn't be worse than this, but it is another investment of time. Should I make the break or sit it out in hopes that the traffic gets moving? I'll go for the east end route. (*Repair.*)

Nightmare: a gravel truck has turned over on the east end bridge as I pass the last off-ramp before the bridge approach. I'm stuck until they get a lane open. It's 7:15 now. I'm not going to make it. Maybe I should rethink my goal. Maybe going standby on a later flight is possible. I don't really have to be on the 8:00 A.M. flight, now do I? Where did I go wrong? I was unlucky, but I also should have known about the construction and left earlier. Next time I have to catch an early flight, I'll add time and do my homework better. (*Redefinition of the goal and reflection.*)

Arrive at the airport by 8:30, book and catch a later flight. (*New goal is reached: solution is achieved.*)

Information Processing Categories for Complex Reasoning Skills

The airport story illustrates the actions and stages of problem solving that can be described by an information processing approach and, in the case of reflection, suggests how learning can take place to improve problem-solving skills. Before we discuss each stage in detail, several comments are in order. First, while the sequence of actions is presented roughly in the order in which these skills would be applied in problem solving, we idealized the example for the sake of exposition. Other actions, in a different sequence, are certainly possible. Evaluation of a problem state, for example, can cause new solution paths to be generated and even prompt reanalysis of the problem. Second, although these activities are generic in the sense that they appear in many problem-solving domains, they are not the sole reason for expertise—otherwise, acquiring them in one context would apparently make one an expert in many domains (Chi, Glaser, and Farr, 1988). Domain-specific knowledge plays an important role, often interacting with generic skills in subtle ways. For example, in the airport example, the ability to generate and evaluate alternate solution paths depends on the driver's knowledge of the local geography and roads. Knowledge of this sort permits us to reduce the amount of search we have to do to solve a problem, to act as more intelligent problem solvers. Some argue that generic skills may be impossible to apply if the problem solver lacks domain knowledge (Resnick, 1987a).

In the following paragraphs we discuss each of the important generic reasoning skills identified in the example.

Recognition of the problem. The first step, a very difficult one in many domains, is recognizing that a problem exists. The problem solver must detect a problem amid irrelevant details in a situation or see an opportunity for action that may not be immediately obvious.

Analysis of the problem. Next, the problem solver must represent the problem in a way that lends itself to solution. This involves specification of the parts of the problem: analysis of start state, determining goal state, identifying constraints and assumptions, identifying resources, selecting alternative representation(s) of the problem, and accessing relevant (domain-specific) knowledge (and not accessing irrelevant knowledge). The problem solver might also consider analogous situations or problems that have been solved in the past and that might act as a starting point for attacking the current problem.

Generation of solution paths. Generating solution paths requires both domain-specific knowledge (e.g., distance to the airport) and domain-general methods. The latter include methods like "means-ends analysis" (identifying the difference between the current state and the goal state and then choosing an action to reduce this difference), simple "forward search" (from the start state to the goal), or "backward search" (from the goal to the preconditions of each action toward the goal). The problem solver may recast a difficult problem in a simpler or more abstract problem space before generating solutions. The simple solution is then extended to the more complicated situation. The problem solver may also employ estimation skills to generate approximate solution paths and then choose among the most promising.

Evaluation of (partial) solution paths, or monitoring as you go. Monitoring the solution path-in-progress may require some specific domain knowledge, as well as general knowledge about what is productive and what is unproductive search. First the problem solver must evaluate the partial solution path based on the accuracy of assumptions, resource limitations (e.g., how much time have I been plugging away at this solution path, given the total amount of time available for the solution?), and other constraints in the problem space. Next, he or she must compare alternate states and select a "best-bet" current solution path to follow. A special case of this is the comparison of two alternate states in which one matches the goal state; then, the desired action is clear. Additional skills are needed to determine if the action taken or the path being pursued has had unexpected good or bad side effects, or to recognize when an impasse has been reached.

Repair. If the outcome of an evaluation is negative, the prudent problem solver will take some alternate actions. It is often useful to first identify what went wrong with the solution. Learning (improvement in future problem-solving performance) can occur when actions that were not useful initially can be altered. This can take place by either changing the conditions under which the action is applied (e.g., add or remove constraints) or making changes in the result of the action such that the nonoptimal path is not generated in the future. Repair can also involve retrieving or regenerating old solution path alternatives to see if one of them would have led to success. Repair, sometimes referred to as "debugging," has been studied in many subjects, including mathematics (e.g., Schoenfeld, 1987) and programming (Kessler and Anderson, 1986).

Reflection (after a solution is achieved). Reflection provides an opportunity for learning or for refining problem-solving skills. In reflection, the problem solver conducts a post hoc analysis of the solution and its generation. Several questions can be asked: Is there some organization to the search that took place? Are there new, larger actions that can be generalized for use in the future? Are there alternate paths that were more or less efficient?

Such questions point the solver toward ways to improve the operators they possess so that search is more efficient in future problem solving.

This breakdown of problem solving into fairly well-defined components of information processing has been applied to many problem-solving tasks and seems applicable across many subject matter domains. In Table 1, we illustrate how the basic concepts of states and operators can be used in several fields of work or vocational education. These, in turn, permit us to understand how the complex reasoning activities mentioned in the airport example apply to other domains.

In the case of interior design, for instance, problem analysis is often critical. The designer must gather information that helps to determine the client's tastes and constraints (analysis of the problem). These, in turn, dictate which design operators (choice of furniture, floor covering, etc.) are "legal." This initial analysis greatly constrains the generation of solution paths. In design, a (partial) solution path is a combination of design components (e.g., putting together a certain wallpaper, carpet, bed, and dresser combination in the bedroom). This solution path is constructed by generating alternative states, evaluating those states, and selecting one of them as the best new state (generate and evaluate). The evaluation of partial solution paths—whether certain combinations "work well" together—is often the most difficult part of problem solving: a skill that distinguishes good from mediocre designers. If a design idea does not work, or if the designer and client cannot agree on the treatment of a room, then redesign has to occur (repair). This involves backing up and reapplying operators (generate), with perhaps a change to the evaluations, or loosening a constraint so that new operators can apply. Finally, a good designer, like a good chess player or electrical technician, will often attempt to learn from a completed solution (reflection), perhaps by discussing the design process and product with fellow designers. Among other things, he or she will try to synthesize new rules for path generation and path evaluation that will avoid any "dead ends" encountered in the recently completed design project.

Let us now consider the example of an electronics technician troubleshooting a nonfunctioning device. First the technician reads the failure report and assesses the failure conditions (analysis). After carrying out a series of diagnostic checks, he or she examines the outcome of those checks (generate and evaluate). If this gives no hints about the source of the problem, the technician backs up and checks, for instance, whether the cord is plugged in and the power switch is in the "on" position. If they are, this means the first solution path is put aside and others considered (repair). It might turn out that the circuit breaker for the outlet has been triggered and there is thus no electricity coming to the wall outlet. If that is the problem, the technician resets the breaker, writes a report, and might discuss it with fellow technicians if the problem and solution present an interesting case (reflection).

SUMMARY

The popular and academic literature on generic skills (including skills referred to as higher-order thinking skills, problem-solving skills, generalizable skills, metacognitive skills, and so on) is awash in definitions and lists and controversy. Based on our analysis of this literature and the perspective of cognitive science, we advance a conceptual framework that posits two broad categories of generic skills: basic or enabling skills and complex reasoning skills. In addition, we assume individuals possess motivational styles and dispositions, distinct from their skills, that influence the effective use of skills. We further define one class of generic skills—complex reasoning skills—from an information processing framework and, in

Table 1

HIP FRAMEWORK AND PROBLEM SOLVING IN DIFFERENT VOCATIONS

	Problem	Start State	Goal State	Examples of Operators and Generic Skills	Constraints
Interior Designer	Design interior of 6-room house	Empty house, floor plan	All rooms furnished and decorated to customer satisfaction	Consult client (analysis of problem) Pick floor covering (generate & eval) Pick fabric (generate & eval) Redesign aspects of den (repair) Discuss design after delivery (reflect)	• Budget • Children • Pets • Location • Customer's taste
Electrical Technician	Why won't this device power up?	Device without power, switch turned on	Device running normally	Read failure report (analysis) Check fuses (generate & eval) Apply meter: measure volts and current (generate & eval) Isolate components (generate & eval) Check building power supply (repair) Report & explain repair solution (reflect)	• Time available • Cost of component • Amount of current • Ease of removal • Access to fellow employees
Secretarial	How do I add three new paragraphs without retyping the entire letter?	Original letter	Letter with the three new paragraphs	Check new material & letter (analysis) Type in text (generate & eval) Delimit old paragraphs (generate & eval) Delete text (generate & eval) Check spelling & correct (eval & repair) Look for future shortcuts (reflect)	• Time available • # times repeated • Access to manual • Quality of manual • Access to others
Clothing Buyer	What style and how many coats should I buy for the coming season?	Need to place order	Reasonable order placed	Read trade journals (analysis) Consult other buyers (analysis) Visit markets (generate & eval) Negotiate prices (generate & eval) Construct order (generate & eval) Adjust order to budget (repair) Compare sales to original order (reflect)	• Time available • Budget • Consumer economic trends • Long range weather predictions • Availability in quantity • Quality of product
Nurse Assistant	How do I answer a patient's question of whether they can get up and take a shower?	Patient in certain condition needs information	Patient content with information provided	Recall or retrieve doctor's orders for patient (analysis) Ask patient: done before? (generate & eval) Assess your knowledge re: this patient & conditions (generate & eval) Ask for advice from nurse (repair) Discuss decision w/colleagues (reflect)	• Time available • Severity of patient problem • Access to fellow employees • Physical appearance of patient
Child Care Worker	How can I best help the lead teacher when some students have finished a lesson early?	Students finish lesson with no alternate work	Early finishers productively involved in some activity	Assess amount of time new task must cover (analysis) Recall alt. activities (generate & eval) Group students at alt. work areas and assign tasks (generate & eval) Reassign as necessary (repair) Discuss performance w/teacher (reflect)	• Time available • Disruption potential of activity • Access to materials • Access to lead teacher • Knowledge of individual student

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particular, research on problem solving, to delineate specific skills that generalize across domains. We then apply this conceptualization to illustrate its usefulness for identifying problem-solving skills in several vocations.

Although this approach to studying generic skills does not completely specify complex causal relationships between motivational factors and generic skills or resolve the controversy surrounding "levels of complexity" of skill (cf. Resnick, 1987a), we believe it provides a good starting place from which to build more precise definitions of generic skills. This approach and problem-solving framework provide the beginnings for a unified model and a specific language for discussing many skills deemed important by vocational educators and employers. In addition, past research in problem solving in academic disciplines, based on the HIP framework, can also illuminate the study of these generic skills in vocational or work-related domains. Perhaps most importantly for those interested in vocational education, the HIP framework, once applied, can identify skills with the precision needed to design instructional methods or curricula to teach generic skills.

To assess the promise of the HIP framework for studying generic skills, we observed vocational classrooms, gathered data on the teaching and learning of generic skills, and analyzed those observations from the framework's perspective. The next section describes the field study and data-gathering procedures. Section IV presents the results of our analysis.

III. THE FIELD STUDY

To observe the teaching of generic skills in vocational education settings, we conducted field studies of vocational classrooms. Several questions guided the conduct of the fieldwork:

- What types of generic skills are taught in vocational education programs?
- What methods do teachers employ to teach generic skills?
- How does the instructional context—i.e., teachers, students, administrative factors—affect the teaching of generic skills?

Our analytic approach combined ethnographic, case-study, and cognitive science methods, which we describe below.

SITE SELECTION

Since our first objective was to observe the types of generic skills taught in vocational education programs, we began by identifying workplace-oriented programs and teachers who purportedly taught these skills. We employed a snowballing or chain-sampling strategy to locate potential sites (cf. Patton, 1980). We began by contacting vocational education experts at a local university and administrators from adult schools, Regional Occupational Programs (ROPs), and school districts in the greater Los Angeles area. We discussed our definition of generic skills with these informants and asked them to identify programs or teachers who taught them. Although none of our contacts, including the teachers we subsequently interviewed, used the term "generic skills," they all understood the concept and were able to recommend several potential sites in the local area or in other states. From this list we selected several technical and nontechnical programs or classes for an initial visit. We targeted both types to determine the translatability of our construct across different programs and occupational domains.

Preliminary visits were made to four classrooms with different institutional arrangements: a junior high school metal shop, a high school interior design class, an aircraft maintenance class, and an evening computer-skills class. During these visits, three or four project staff members observed classroom instruction, discussed teaching and learning generic skills with the teacher, and informally conversed with students. Project staff members submitted written reports of their observations and discussed the merits of each site with respect to the needs of the research study.

We observed what we considered the teaching of generic skills in all of these classrooms, and selected one—the high school interior design class—for further intensive study. This class seemed an ideal candidate for several reasons. First and foremost, several aspects of the class we observed and the teacher's plan for the course highlighted generic skills instruction. For example, the teacher conducted what she termed a "consensus" exercise, in which students were required to make group decisions about fabric selection for a living room designed for a hypothetical client, justify their decisions on the basis of known facts about certain fabrics, and provide rationales for their decisions to the group. This exercise gave students practice in choosing the optimum of a set of plausible alternatives, providing a rationale for a decision, and negotiating in a group to arrive at a consensus decision. In addition, the major activity in

the class consisted of a group project in which each group was tasked with designing the interior of a six-room house. This activity was essentially an ill-defined problem that would require students to apply the kinds of problem-solving skills that are central to our conceptual framework. Thus it gave us the opportunity to see how students, as individuals and as a group, approach this problem and how the teacher organizes instruction and teaching actions to support it.

Second, the teacher was vocal about the importance of teaching generic skills and showed enthusiasm for our research project. Both she and the students seemed comfortable with our initial visit, which indicated that the research team would not be overly intrusive to ongoing classroom activities. Finally, this class was administered through an ROP at a local high school where we had conducted several other studies in the past several years. From this other research (on the use of an intelligent tutoring system in algebra classes), we had knowledge of "traditional" academic instruction, the student body, and the broader community. We expected that this prior experience would be useful for understanding important contextual factors that can influence the success or failure of any instructional program. It also provided a potentially interesting way to observe differences between academic and vocational instruction *in the same school.*

While our small, nonrandom sample does not permit the statistical inference needed for a claim of generalizability of findings, we set methodological conditions to achieve comparability and translatability. Our sampling strategy, the explicit delineation of generic skills and teaching methods using cognitive science frameworks, and our cross-site analyses for common instructional themes, support comparability and translatability and provide the foundation for comparisons in qualitative and naturalistic research.[1] Thus, we recognize that while an intensive case analysis can provide rich hypotheses in an exploratory study such as this, the results may have limited generalizability and will need further verification.

CLASSROOM OBSERVATIONS

To gather data relevant to the second and third questions—what methods do teachers employ to teach generic skills and how does the instructional context (teachers, students, administrative policies) affect teaching?—we conducted an intensive case study of the interior design class. We visited the class 18 times over the course of six weeks and were thus able to observe the class on a regular basis as the groups carried out the class project. That project involved completing a contemporary interior design for a historical Victorian house. Students were told to research the original house and the design tradition, draw the house, draft the floor plan, select furnishings and coordinate colors, and prepare boards to display their proposed design. The majority of students worked in groups of four to six people, although several students worked individually. Grades were awarded for the project, with the expectation that while certain tasks would be completed by individual members (e.g., the floor plan and the drawing), other tasks (e.g., the furnishings selection) would be a group product. The project grade served as the final exam grade. Students were given six weeks to complete the project. The group made decisions about the task assignments, although the teacher made the various group assignments.

Research project members submitted a field report for each class, which included the following kinds of information: physical layout, students, teaching activities (e.g., lectures,

[1]For additional reading in qualitative methodology see Goetz and LeCompte (1984) and Lincoln and Guba (1985).

individual instruction), group activities, and project progress. To provide an in-depth description of the learning context and culture, we used ethnographic methods, including participant observation with project groups, systematic five-minute spot observations among groups, and a "found objects" assessment (e.g., changes in the physical environment that provide clues about the learning culture and project progress; cf. Spradley, 1979; Green and Wallat, 1981). Following a common notion in ethnomethodological research—that language tells the social reality, describes and constitutes it as well—we focused our observations on teacher-student and student-student interactions (cf. Coulon, 1987). That is, we sought to understand the types of generic skills being taught and the teaching methods used by focusing on the interactions taking place over the six-week project. Staff also met weekly to discuss their observations and to begin to develop a collective picture of the class with respect to teaching and learning generic skills.

We coded our field notes (as well as the interview data discussed below) with *The Ethnograph* (Seidel, Kjolseth, and Seymour, 1988), a computer-based analytic tool.[2] Using our conceptual framework and domains derived during observations as indexing terms (e.g., learning environment, teacher practices, learning outcomes, dispositions, group work, individual workers), we coded data and used *The Ethnograph* to sort them throughout the entire data set. Frequently occurring codes, and those expected but seemingly absent, were reviewed by the research team. We sought to understand several issues, including how educational and classroom norms might be breached in this setting yet still permit learning to proceed.[3]

ASSESSING THE INSTRUCTIONAL CONTEXT

Finally, we wanted to examine the broader instructional context within which generic skills programs or curricula are taught. In addition to classroom instruction, student, teacher, and administrative variables can influence program outcomes. Students' background or demographic characteristics, abilities, and attitudes may affect program success. Content and format of vocational programs may differ, for example, for white and minority students (Oakes, 1986). Students in programs viewed as "special," like those fostering generic skills or other innovative curricula or teaching practices, may be highly selected to ensure program success. Teaching can be influenced by, for example, teachers' personal control over their working environment, workload requirements, peer relationships, and distribution of resources. District policies and administrative attitudes can either help or hinder the teacher's ability to instruct and the student's opportunity to learn.

To gather data on the broader instructional context, we examined relevant documents, conducted extensive formal interviews with the interior design classroom teacher and school-

[2]*The Ethnograph* permitted organization of our data set, some 300+ pages of text, into relevant sequence and topics while establishing an audit trail. It facilitated data reduction by permitting assignment of codes to sections of text. The text could then be sorted according to codes (e.g., learning environment, teacher practices, dispositions, group work) to reveal patterns across the separate observations. As themes emerged, codes could be recoded and merged. Thus we were able to index complex passages of text while maintaining the whole and merge data as themes were revealed.

[3]We treated our prior experiences as alternative hypotheses. Since these experiences influenced the types of a priori assumptions we brought to this study, we opportunistically examined our assumptions about classroom and teacher activities when our observations rivaled those assumptions. For instance, instead of judging a teaching practice as "poor" on the face of things, and thereby biasing our future observations, we sought to understand why we made a judgment and then gathered data about the teacher's intent, teaching practice employed, and student response. This approach provided an *interpretive* lever for our analysis—understanding factors that drive behavior, in this case teacher practices associated with learning generic skills. For additional reading, see chapter 1 in Geertz (1983), on thick description and the interpretive theory of culture, and chapter 6 in Guba (1978), on the evaluation of hypotheses.

level administrator, conducted brief, informal interviews with other classroom teachers and administrators, interviewed a local employer who hired students from the interior design class, and administered a student questionnaire. Since it was beyond the scope of this study to examine the myriad contextual variables that may influence program implementation and outcomes, we focused our efforts mainly on examining teacher, student, and administrator beliefs about the importance of generic versus specific skills in the curriculum and how they might best be taught. Of particular concern were the attitudes and beliefs of all of these actors toward the importance of learning generic skills and their applicability to post-school employment. We discuss the interview instruments in more detail below. We also examined school or district policies that affect the program and classroom (e.g., availability of resources, local or outside funding, links to the business and industrial communities).

Interviews

Our formal interview instruments were designed to carefully assess respondents' perceptions about and experiences with the learning of generic skills and how they viewed key school and educational policies and teaching practices that potentially influence classroom instruction and curriculum. Because we were interested in implementation issues and the possible expansion of generic skills instruction within the vocational curriculum, we also asked the teacher and administrator to speculate about how they thought proposed policy changes might influence their program and classroom. These interviews took place after we had spent some time in the classroom. In this way we were able to fold our observations into the interview questions, asking for explanations and insights. During interviews we asked respondents first about their perceptions, then sought specific examples or probed for contextual issues known to make a difference in other vocational education settings.[4]

The administrator interview gathered information on the Regional Occupational Program that administered this class in this school, and on district-administered vocational and academic programs. Specific questions covered, for example, budget allocation, curriculum, and student enrollment and placement. From answers to these questions we learned about vocational education's role within the school and the degree to which vocational education concerns are isolated or fragmented. Additionally, we asked about teacher selection and evaluation and the quality of communication with employers.

The design teacher interview focused primarily on classroom and student issues, although we were also interested in how much the teacher participated in the whole school program. We saw the interview as the opportunity to learn whether what we interpreted as "different" teacher behavior was in fact planned and supported by the teacher's own personal educational philosophy. Therefore, we questioned the teacher about classroom norms, assumptions about students' ability, the class orientation as vocational or workplace-related, and the types of entry-level employment expected as the result of the class.

The employer interview centered on learning what entry-level skills employers value and how the employer facilitates the learning of generic skills when an employee lacks them. We also asked the employer to evaluate the workplace performance of students placed through the interior design ROP program we studied.

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[4]One concern with open-ended questions is that the responses may reflect what respondents think the interviewer wants to hear or the respondents' *espoused* views rather than ones they operationalise or have experienced. For example, we were looking for more than simple lip service to the view that "problem solving is important," by probing for evidence that such a view is reflected in an individual's teaching practices, e.g., structuring projects to promote problem solving, or developing lessons and staging practice in the "consensus process."

Student Questionnaire

The student questionnaire was designed to provide information about student coursework, why students enrolled in the class, how the class fit into their future plans, and their views of the content of the class. Specifically, we were interested in assessing whether the students perceived as important or useful the generic skills being emphasized in the course. Having spent a considerable amount of time in the class before constructing this questionnaire, we had a fair idea of what the teacher intended as instructional goals. Hence, we designed a series of statements against which students could rate their level of agreement on a scale of 1 (strongly disagree) to 4 (strongly agree). For example, the statement "It's important to back up your opinion with facts" relates directly to the teacher's goal that students learn to justify their design choices. The statement "It's important to learn to work in a group" refers to students' feelings about group project work. The questionnaire was distributed on the day before the presentation of final projects.

IV. RESULTS

In this section we address three issues:

- What generic skills and dispositions were taught and learned. Here we are mainly concerned with the educational content of instruction.
- How learning and teaching proceeded. Here we focus on the specific pedagogical tools and techniques the teacher used to communicate the chosen content.
- What factors contributed to the teaching and learning environment. This analysis steps back to look at the constraints and forces that shaped the teacher's content as well as pedagogy.

Our analysis and discussion of the learning and teaching content in the vocational classrooms we observed consider, first, the "knowledge goals" embodied in the curriculum—that is, the kinds of skills and knowledge the teachers were attempting to help students acquire. The analysis also considers broad curriculum decisions, such as which aspects of a subject area to emphasize. Research on teaching (Collins and Stevens, 1982; Leinhardt, 1983; Leinhardt and Greeno, 1986) and one-on-one tutoring (McArthur, Stasz, and Zmuidzinas, 1990; Putnam, 1987) reveals that teachers' planning, instructional activities, and teaching techniques are organized around their curriculum goals. We attempt to understand why the teachers believed these goals important. Next, we specifically examine the teaching and learning of generic problem-solving skills and dispositions, as defined in Sec. II. Our analysis demonstrates that although generic skills comprise some of the knowledge and curriculum goals, they were not necessarily the only skills learned nor, perhaps, even the most important ones. Dispositions were given at least equal consideration.

Our analysis of how teaching and learning proceeded includes the techniques the teacher used to communicate information and make the important lessons and knowledge clear to students. We also discuss how the classroom environment was configured to support the learning of targeted skills, knowledge, and dispositions. Many features we observed do not typically appear in many academic high school classrooms and, indeed, often pose organizational and administrative difficulties that those teachers cannot overcome. Much of our analysis of how the classroom environment was organized to support learning involved discerning how these features were converted from apparent costs to benefits. In addition, we discuss teacher techniques and other aspects of the environment that appeared to enhance student learning, as well as behaviors and organization that appeared counterproductive.

Finally, we discuss why the teaching environment was structured as it was. Rather than looking at internal classroom factors, this part of the discussion examines the external forces that shaped the classroom or the circumstances that permitted the teacher to create the desired environment. We include here a discussion of how workplace demands, the constraints of the Regional Occupational Program, and the teacher's educational philosophy affected the interior design class.

The analysis is primarily, but not exclusively, descriptive. In most cases we will discuss the teacher's knowledge goals and techniques with minimal commentary on their real impact on student learning, since we have little data that bear on this issue. In many cases our evaluative or prescriptive views are implicitly positive. For example, the teacher techniques for controlling the "chaos" that arose when students worked on projects appear to be generally

creative solutions to difficult teaching problems. However, in some cases we do make explicit evaluative comments. These usually refer to costs associated with a teaching decision—which may or may not have been anticipated by the teacher—and alternative teaching choices that were not selected but may have had important advantages.

As we described in Sec. III, we made observations in four classrooms. Results and examples reported below are derived primarily from the interior design class (the subject of our intensive study) and the metal shop class, but they include observations from the other classes as well.

KNOWLEDGE GOALS: WHAT WAS TAUGHT AND LEARNED

To understand the educational content of the classrooms, we must look at the knowledge goals in the classrooms—the particular kinds of information, beliefs, or skills the teachers wanted students to learn. The first few observations focus on specific kinds of generic skills we observed being taught. These included domain-specific goals (e.g., knowledge of different types of fabric and their characteristics) as well as domain-independent skills. Here, of course, we focus on the latter type and provide examples from different classrooms. We also mention some important content the teachers did *not* want students to learn. Finally, we examine how teachers attempt to impart several important dispositions and attitudes.

1. Generic Problem-solving Skills

The teachers we observed had been chosen for study because of their interest in teaching generic skills in addition to, or in place of, subject-specific skills. We therefore expected to see the teaching of some of the complex reasoning skills mentioned in Sec. II. The following subsections discuss the main generic skills in this category that were taught.

1a. Repair skills and learning from errors. Teachers encouraged students to try out different ideas without fear of failure.

> EXAMPLE: Mr. Smith,[1] the teacher of junior high metal shop, said he thinks kids learn from mistakes "because they don't remember when they get it right." Mistakes, he claimed, serve to focus their efforts, and when they correct a mistake, they will remember what they did. His behavior was very consistent with his view. A student might ask him how to do X (e.g., cut a hammerhead); Mr. Smith will not tell the student how to do X, but challenges him or her to figure it out. The student will go away and try it. Mr. Smith monitors the student's progress, but does not interrupt until the student has made a mistake that he or she cannot recover from.

Students learn from errors only if they are willing to try ideas that may result in mistakes. Hence learning from errors as a generic skill is obviously very related to a disposition for boldness in decision making. Bold decision makers are willing to accept the negative consequences of their choices, and more important, they possess the skills to fix them. Later we discuss "boldness in decision making" as well as more general interrelationships between dispositions and skills.

1b. Skills for dealing with authentic problems. The classroom environments defined by the student projects gave rise to situations in which several kinds of important

[1]To ensure anonymity, teachers and students have been given pseudonyms.

generic skills could naturally be learned. In the case of learning from errors, the teachers frequently provided active coaching and support for learning. With the following skills, however, teachers generally did not provide active coaching but instead structured the physical environment (in ways we elaborate below) so that students had an opportunity to learn the skills or, at least, to be exposed to them.

- *Analysis of problem and generation of solution paths.* These two categories appeared as we saw students define their own problems and solution space. For example, teams had to identify the criteria for project completion, determine how to get there, assess whether any team members had special skills that could be used effectively (e.g., artistic talent), and determine the whereabouts of needed information.
- *Evaluation of (partial) solution paths, or monitoring as you go.* Students had to determine, for example, how to best use their resources to complete some project requirement and what criteria to use to signal its completion. Since students were not given deadlines for completing some projects or parts of projects, this required them to organize their own goals and monitor their progress over relatively long periods of time—often several weeks. Therefore, students were given opportunities to learn important planning skills.
- *Generation of solution paths and repair.* Students had the opportunity to deal with multiple possible solutions. None of the projects given students had a single (or even finite number) of well-defined "correct" solutions. There were many ways of designing a house or building a hammer that would "satisfice." Students thus had opportunities to deal with problems for which there was no single optimal solution, and to change direction if a chosen solution path did not work out.

2. Deemphasis on Subject-specific Skills

Since we chose to observe teachers who emphasized teaching generic skills, it is not surprising that subject-specific skills in two classrooms (interior design and metal shop) were often downplayed in favor of generic skills.

> EXAMPLE: Mr. Smith lets students file metal in technically inferior ways—using both forward and backward strokes—instead of demanding correct filing (forward only). He is aware of this problem but believes it is a small price to pay when giving them the opportunity to learn and perform independently.

Mr. Smith consistently emphasized to students that how a goal was accomplished was relatively unimportant, as there were always many ways to solve a problem. Hence he placed relatively little emphasis on specific procedures, except when safety demanded particular use of a tool.

Ms. Adams, on the other hand, valued subject-specific skills more highly than did Mr. Smith, and she lectured more frequently in her interior design class. But she spent even more time coaching students in generic skills than on lecturing, which was consistent with her belief that they would be more important in students' future jobs. For example, Ms. Adams gave very detailed lectures on fabrics but did not test students' retention of this material. Almost all of a student's grade depended on her evaluation of the class project.

3. Deemphasis on All Students' Reaching a Uniform Level of Performance on Well-defined Sets of Skills

In many academic high school classes, students are required to learn a single, relatively well-defined set of skills or knowledge. Students' grades are generally determined by their performance on tests that all the students take. Many schools also administer district- or state-mandated standardized achievement tests, or they may measure their effectiveness by student performance on Scholastic Aptitude Tests or the like. Unfortunately, teachers often thus gear their instruction to these tests, which can seriously limit teaching and curricular innovation (e.g., Koretz, 1988). Neither Mr. Smith nor Ms. Adams graded in this way. They judged students on the basis of their performance on class projects, and this permitted teachers to personalize assessment.

> EXAMPLE: Ms. Adams permitted at least two kinds of nonuniformity in assessment: (1) On projects, students could choose the tasks that they wanted to do from the set of tasks that made up the whole. This allowed a student with little artistic ability, for example, to do background research as his contribution to the group project. (2) Students' grades depended less on the excellence of their results (project) than on the teacher's estimate of how far they had come during the semester. We noted that several students with only average-quality projects received relatively high grades.

This deemphasis on uniform skills is perhaps consistent with the deemphasis on domain-specific skills. That is, well-defined, subject-specific skills were in part replaced by relatively "ill-defined" knowledge that falls outside the standard subject curriculum. The teachers exploited the flexibility this ambiguity implies to tailor their evaluation of students.

The decision to personalize evaluation can also be viewed as a natural response to student diversity in vocational classes, be it ethnic, racial, experiential, or academic. However, it is important to note that to these teachers, different standards of evaluation did not mean *lower* standards for some students. The teachers simply required students who were not strong in one area to show excellence in another.

> EXAMPLE: A student was placed in Ms. Adams's class fresh out of drug rehabilitation. Ms. Adams noted over time that his reading, writing, and spelling skills were too poorly developed to allow him to express his understanding of and ideas about interior design, and his exam score suffered. In order to challenge his artistic talent and evaluate his growth in the class, she assigned a difficult architectural drawing. He did a fine job on the project and was quite proud of the result. Now more willing to accept his talent, the student found steady employment at a wallpaper store.

This type of individualized evaluation seems suited to the realities of the workplace. Many jobs involve several kinds of skills, and few people show uniform performance overall. For example, one secretary may be skilled at scheduling meetings or doing administrative tasks, while another is better at composing letters and editing manuscripts. Overall, each may be a good and efficient secretary, but each has a different profile of strengths and weaknesses.

4. Emphasis on Acquiring Generally Useful Attitudes and Work Habits

Because subject-specific knowledge was deemphasized in these vocational classes, perhaps the main focus was the learning of what we refer to in our conceptual framework as dispositions. Teachers emphasized many dispositions or attitudes aimed at encouraging students to

become independent problem solvers, taking advantage of the privileges of this independence and also fulfilling the responsibilities it implies. Below we list a representative set of the specific attitudes the teachers emphasized.

4a. Ability to make decisions. As we discuss below, teachers structured projects so that each student, and each project team, was forced to make decisions about what to do and how to do it. In contrast with a traditional mathematics class, for example, where students have well-defined problems to solve and well-defined routes to determine the correctness of their solutions (ask the teacher, look at the answers in the back of the book), students in these classrooms generally had to define their own problems, find their own tools for solving the problems, and judge their own solutions.

> EXAMPLE: Ms. Adams's interior design class project involved decorating six rooms in a house. While some aspects of the project were constrained (e.g., a board showing the design of each room had to be completed, showing carpeting, wallpaper, etc.), she deliberately underconstrained the task to encourage students to "think creatively."

This emphasis on students making their own decisions extended beyond global structuring of the course to very local interactions with students.

> EXAMPLE: When a girl cannot get her hammerhead out of a vice (even with the help of a couple of other girls), Mr. Smith does not go over and do it for her. Rather, he asks her what she would do if he weren't around, thereby making the student find her own solution. She requests help from one of the boys, who frees the hammer.

> EXAMPLE: A student asks Ms. Adams about chinty (a flower-designed pattern). He shows her a peach-colored sample of wallpaper and asks, "Do you like that?" *Ms. Adams*: Does it look okay to you? *Student*: I guess you can't give a technical answer to that, can you . . . it's like me asking you what to write. *Ms. Adams*: It's not important if "I would personally go with it." What's important is would it be wise. As a rule a designer goes with something different. That's why people pay you.

4b. Taking responsibility for your own decisions; devaluing appeals to authority. As the above example shows, teachers consistently deflected requests for information and help when they knew students could solve the problem themselves. More generally, they emphasized that the students could not rely on the teacher's authority as a crutch or as a means of getting easy answers and simplifying their problem solving. According to the teachers, this illustrated for the students the other side of independence: You not only get to make your own decisions, but you have to implement them and stand by them. A consistent message to the students was that *they* were responsible.

> EXAMPLE: A student comes to Mr. Smith and asks how to cut the wedge out of her hammer. He engages the student in a dialogue about this but will not answer directly. He challenges her to "use your brain" or "figure it out yourself." He is careful not to frustrate her (often this is what he used his humor for), but still he gives her no information. His action has the desired effect. She thinks for a bit, looks at what other students are doing, and sees that a saw will do the trick.

One interesting consequence of the teacher's withdrawal of authority and assistance was that students were forced to learn to help one another and develop some cooperative skills. In the example above, the teacher also inadvertently teaches a technique that the student can use to solve problems: search for clues in the environment.

4c. Boldness in decision making. Teachers recognized that many students are very reluctant to make significant decisions, and they countered this tendency by encouraging students to be "bold."

> EXAMPLE: Bob shows Ms. Adams a wallpaper sample in beige. Ms. Adams looks at it and asks Bob if he can't "come up with something less safe." Bob, looking puzzled, asks what is wrong with beige. Ms. Adams turns the question around, but Bob cannot respond. She explains that beige is not a design challenge: "There is nothing to do with it. You can't make a mistake with it."

Stressing boldness in decision making reflected the teachers' concern that many classroom experiences teach students to fear "standing up for themselves." From an interview with Ms. Adams:

> *Ms. Adams*: If I had spoon-fed the kids, it would have defeated the whole purpose of the project; they would have never shifted gears. They were frustrated when they didn't get the answer, but they learned that it's okay for them to have an opinion as long as it's backed by a rationale. . . . Liking something is not enough. When you don't give your opinion you give away your power—classes usually teach kids to fear standing up for themselves. *Interviewer* (paraphrasing Ms. Adams): School beats power out of the student? *Ms. Adams* (chuckling): Hey, that sounds like something I might say . . . you're right, and it's a rude awakening. Where do students get a class in it? . . . I try to teach them "don't be afraid to be bold."

As the above example indicates, part of the reason teachers stressed dispositions (as opposed to generic or domain-specific skills) was their belief that at least some of the important lessons their students needed to learn had little to do with traditional classroom teaching. Our observations indicated that teachers felt genuine concern that students often had low self-esteem, and they believed that part of their responsibility was to deal with motivational and affective problems as well as cognitive ones. Aware that their students had very urgent problems to confront in their lives, teachers thought they ought to provide students with values and broad attitudes with which to tackle these problems. Further evidence of the teachers' concern with this knowledge goal comes from interviews. Both Mr. Smith and Ms. Adams displayed great knowledge of their students' lives and problems *outside* school. They were clearly concerned with each student's general state of well-being, not just his or her intellectual advancement. In general, many of the teachers' knowledge goals for students can be understood only from this perspective.

4d. Learning the parameters of workplace situations. The teachers also made efforts to help students appreciate the contingencies of the world outside school. Teachers deliberately attempted to make the classroom environment closer to the authentic work environments in which these students will eventually find themselves. By the same token, they were aware of the artificial aspects of typical classroom environments.

> EXAMPLE: Ms. Adams noted several ways she sees typical classroom environments not setting up realistic problem-solving situations. These included structuring situations in which (1) there is usually one and only one "right answer," (2) the teacher is the main or sole source of information as well as judger of performance, and (3) there is a single, well-defined set of skills that all students must learn. Ms. Adams indicated that she attempted to structure classroom tasks so that many solutions were possible. Thus students would, within reason, develop their own standards by which to judge products and learn that various kinds of skills could be rewarded with good grades.

In making the classroom a relatively authentic experience, the teachers did not shy away from exposing students to some of the harder realities of the workplace. For example, if students complained about deadlines, they were often reminded that in the workplace a missed deadline has serious consequences.

> EXAMPLE: In Ms. Adams's class, as the deadline for project completion nears, she is met with complaints that students did not know about some deliverable, or could not find the materials necessary to complete their work. Ms. Adams responds, "Do what you can at this point. That's all you can do." She mentions that this is what happens in the real world of design, too.

The following example also demonstrates how Ms. Adams has at least an intuitive understanding of Weiner's (1986) attributional theory of motivation. According to this theory, students who attribute prior success to stable factors (e.g., high ability or an easy task) should hold higher achievement expectations than students who stress unstable factors (e.g., high effort or good luck). Ms. Adams wants to discourage "bad luck" as a reason for poor performance.

> EXAMPLE: When told that a floor plan is missing, Ms. Adams will first ask the student, "How long has it been missing?" If it has been lost longer than a few days, she will not accept the excuse because the student made a conscious choice not to take care of the problem. She reasons that when one is in business and something comes up missing, the customer or boss is not going to accept a bad-luck story. She tries to stop this type of habit because it becomes a lot easier to "use" bad luck as an excuse the second time around.

We classify the teachers' lessons about the workplace as dispositions since, in most cases, the lessons stopped short of training students in specific skills they might require to carry them out. Rather, the focus appeared to be more on giving students an appreciation of the contingencies and constraints they could expect to encounter and on inculcating the broad habits that would be necessary to deal with workplace problems.

4e. Emphasizing ends over means. An attitude related to simulating workplace situations in the classroom involved the distinction between the end result of a task and the process one uses to get there.

> EXAMPLE: In an interview, Mr. Smith espoused a strong belief in "function over form." He related his experience in the Israeli army, where, as an air force mechanic, he was often forced to fix aircraft using tools and parts that had to be made impromptu to fit the required functionality. This was consistent with his stated philosophy of education: the main issue is the final product—either it works or it doesn't—and students can use whatever means necessary, as long as it works. His belief was also consistent with his classroom behavior. Mr. Smith did not watch students closely to see how they were cutting their hammerheads or drilling their holes, except in a few cases where a student was doing something dangerous. But when students showed him what they had done, he was quick to judge whether the quality was adequate.

4f. Encouraging questioning of authority. In stressing ends over means, the teachers were communicating to students that there are often multiple ways of solving problems, and that it is frequently counterproductive to adhere unquestioningly to many "rules of behavior." This attitude clearly extended to their own behavior (a fact that was not missed by

the students). Neither Ms. Adams nor Mr. Smith held school bureaucracy in great respect, nor did they always follow school procedure.

> EXAMPLE: Ms. Adams noted that the school committees studying the improvement of teaching skills are ill advised because "committees, [and] the school board are about talking, not actions. Teachers need to stop studying problems and start doing . . . I come from an industry that must do, not just talk."

Both teachers challenged school norms but found ways to participate in school activities and yet remain autonomous. They both felt that "correct form" impeded useful functioning in their classrooms. In short, they had adopted the attitude of questioning authority and norms, and through their behavior, they encourage the same in their students. One student challenged authority as follows:

> EXAMPLE: A Chicano student had no use for the assignment to design a six-room Victorian house for his final project, and declared that he would design a one-bedroom house for a "poor Mexican family." This change in plan meant, of course, that his project work would be significantly reduced. Ms. Adams did not object outright, as she accepted his message that history, for him, meant "Mexican." In an effort to push him to do an equally complicated project, she said, "Hey, get with it! Design it for a rich Chicano who made it in the barrio . . . who wants a real classy place to live and enjoy his money." The student switched gears and, by the completion of the project, had discarded all his initial selections and replaced them with more sophisticated designs in the Southwestern tradition.

Teachers encouraged a questioning attitude in the classroom, while fostering project progress and learning. Classroom management was a balance between respect for students on the one hand and control over the classroom on the other.

> EXAMPLE: In her interview Ms. Adams commented that "classrooms that are bound and determined that academic achievement will take place" do not offer an environment where students are "required to take responsibility for choices because the right answer is what they [teachers] look for. But what happens when the right answer changed and it wasn't in the textbook and the teacher didn't know it because the teacher stopped learning? These kids are smart, and some days they have the answer and you don't." She then added emphatically, "My classroom is not a democracy and kids know it. I've got to have some control over these tough characters."

> EXAMPLE: Mr. Smith calls himself a dictator in his classroom, and he is, when it comes to the quality of his students' work. Otherwise, the shop has a highly social atmosphere with a lot of joking and moving about as students work on individual projects. He also speaks of "scratching your boss's back." He wants his students to *carefully* pick their battles with authority.

5. Cooperative Skills

Several factors conspired to make cooperative skills important in the classrooms. First, the group projects in Ms. Adams's class required students to work together. Cooperation was explicitly sanctioned and discussed, using the term "consensus process." This denoted a procedure whereby the student made a decision (e.g., selecting fabric) by offering a choice and at

least one reason to justify that choice (the rationale). Other students were required to respond to the choice and debate it in terms of the offered rationale. Ms. Adams described consensus process in considerable detail at the beginning of the course, although later in the semester she did not focus on it explicitly.

> EXAMPLE: Karen, a student with several leadership positions in school, did not want to work with a group that had chosen another leader. For a while she stopped coming to class, and then she participated in group decision making reluctantly (she did not like her group's choices, either). Karen admitted that she was angry because she did not know how to be part of a group and not lead. After a while, bothered that she was letting the group down, she decided to get involved again. In the end, she felt she had made a contribution and that the final project was good. Although she was fully aware of this situation, Ms. Adams did not intervene except to let Karen know that she expected her participation. According to Ms. Adams, this is how she forces students to take responsibility for their own actions. For Ms. Adams, this was a particularly important lesson for the workplace: "What happens when Karen is at a negotiating table and things aren't going her way? . . . If she walks, she's gone. Now, wasn't that a wonderful lesson to learn at 17?"

By contrast, Mr. Smith rarely called explicitly for cooperation, as projects in his class were carried out individually. However, as we noted above, we observed considerable cooperation arising out of Mr. Smith's insistence that the students use the environment to solve their problems, rather than relying on his authority and expertise. In addition, as we discuss later on, Ms. Adams and Mr. Smith both employed master-apprentice teaching styles that engendered cooperation.

Summary: Relationships between Generic Skills and Dispositions

To summarize, our analysis identified several kinds of generic skills that were the focus of teaching. However, the teaching of these reasoning skills was more implicit than explicit. For example, Ms. Adams's project-centered curriculum structure provided an ideal forum for teaching students about a broad range of generic skills, such as subgoal decomposition, hypothesis generation and testing, and so on. But instead of explicitly teaching the steps of a problem-solving process, she structured the environment to induce students to use them. How she accomplished this, and the implications of this approach for learning, are discussed in the sections that follow.

In addition, we found that teachers emphasized dispositions—attitudes and general work habits or ethics—over complex reasoning skills or domain-specific skills. Furthermore, the dispositions and attitudes we observed are related in interesting ways to generic skills. In general, we can think of the attitudes as general cognitive dispositions to act. For example, the attitude of "think for yourself" or "use your brain" is essentially an exhortation to marshal one's cognitive and affective resources in the service of a problem or goal. Dispositions, therefore, do not take the place of generic problem-solving skills. For example, when you have decided to allocate resources to solve a problem, you still need to invoke skills that will, say, decompose your main goals. Without such basic attitudes, however, a student may never be in a position to attempt to exercise or learn important problem-solving skills. If a student does not believe he is responsible for solving a problem, he will often do the minimum amount possible to deal with it. In such cases, students' "mindless" approaches to problems may subvert

attempts to teach them useful problem-solving skills. In some sense, then, having the productive attitudes discussed here is prerequisite to learning and using many other generic skills. We believe that in many cases our teachers, recognizing that their students lacked these basic attitudes, focused on imparting them rather than teaching more sophisticated reasoning skills. Interestingly, this conclusion appears consistent with several studies in which employers were interviewed about desirable employee traits (e.g., Brown, 1988; Carnevale, Gainer, and Meltzer, 1988; Michigan Employability Skills Task Force, 1988). While subject-specific and complex reasoning skills were high on the lists, attitudes and work habits (e.g., an ability to show up for work on time) were equally stressed.

HOW THE CLASSROOM ENVIRONMENTS SUPPORTED LEARNING

In this section we look more at the *how* of learning than the *what*. Instead of examining the content of the knowledge communicated, we discuss some of the factors that might have contributed to the success of the classrooms as learning environments. In examining these factors we do not restrict ourselves to only the teachers' techniques for conveying major lessons. While such techniques are important, we also examine the physical and social structure of the classroom. Our view is that the teacher is just one of several tools in the classroom environment that can support learning.

Our analysis of the factors contributing to learning is more formative than our assessment of generic skills and attitudes being taught. To understand the knowledge that was the focus of learning and teaching we were able to rely on an extensive literature in cognitive science. That work provided a theory that describes relatively rigorously the structure of some generic skills, yielding a list of features we could expect to see in the field. However, with few exceptions, there is no similar, broad theory of how environments can be configured to support the learning of such skills. The work of Collins, Brown, and Newman (1989) on cognitive apprenticeship provided a main theoretical foothold for our analysis.

We divide the discussion of classroom environments into several different categories.

- Features of the curriculum, course content, and the classroom.
- Teaching policy: overall properties of the teacher's approach to teaching in the classroom.
- Teaching techniques: more specific techniques used by the teacher to further his or her knowledge goals for the students.

We discuss each category below, first describing our observations, then speculating on how each supported the knowledge goals delineated in the previous section.

Features of the Curriculum and Classroom

1. Project-based. The dominant feature of the classes was that students learned while doing projects. In the vocabulary of Collins, Brown, and Newman (1989), learning was "situated." In Ms. Adams's class, for example, students worked in groups of three to five on a single project that lasted approximately six weeks. In Mr. Smith's class, projects were individual, and several (up to five or six) were completed in a semester. Although both teachers provided lectures and demonstrations (where all students watched the teacher perform some task), these activities accounted for a relatively small percentage of classroom time and were always

given in the context of information needed by the students to complete projects. In both classes, grades were determined almost exclusively by performance on the projects.

Several features of the projects are worthy of note. First, the tasks appeared to have some authenticity. In Mr. Smith's class, a project's authenticity was guaranteed by the fact that, when complete, it resulted in a usable object (e.g., a hammer). Since students were free to choose their projects (within limits), they could plan to build artifacts that were potentially valuable for them. In Ms. Adams's class, authenticity derived from her personal interest in interior design. As a working professional in that field, she attempted to structure student projects to resemble, at least in form, the sort of project actually produced in professional interior design firms.

> EXAMPLE: At the completion of the project, students were required to present their work. In preparation for this presentation, Ms. Adams modeled how presentation boards (containing selections of materials for each room) should be designed. She explained that such presentations were crucial in selling the client. In addition, students were required to prepare project budgets and telephone manufacturing firms to get actual prices.

Ms. Adams also frequently used "war stories" to teach students a particular lesson or communicate about the project. For example, she explained why linen drapes are a poor choice by relating a story about a client who had insisted that she use linen for the drapes. This choice proved disastrous, because linen reacts to humidity: when it was damp the drapes sagged and lost their pleats, when dry they shrank and wrinkled. War stories—the anecdotal retelling of experiences to one's associates on the job—have been shown to be a very effective means for teaching and learning diagnostic skills in a community of workers (e.g., Orr, 1986).

Second, perhaps partly because of their authenticity, the projects generally appeared to be intrinsically motivating. Overall, students were on-task a high percentage of the time. In Mr. Smith's class this was uniformly true. In Ms. Adams's class, at the outset students were not fully engaged with the task and often attempted to look busy without working. By the end of the project, virtually all the students seemed heavily involved.

Relationship to knowledge goals. The fact that the projects were motivating to students generally insured a high time-on-task, so most students were exposed to many potential learning experiences. The relative authenticity of the projects meant that the students were in learning environments whose lessons were possibly valuable. The use of an authentic task clearly reflected the teacher belief that exposing students to practical work lessons is essential.

Designing the projects to last for fairly long periods permitted students to be exposed to problem-solving challenges that students in many classrooms rarely see. In academic classes, for example, typical student tasks begin and end in a relatively short time (less than an hour in math classes, perhaps a few days in classes such as history). Consequently, students are rarely required to manage their own time or decide how to organize or decompose large goals into subtasks. In addition, although many academic classes give students opportunities to cooperate, the period is typically too short to be of much instructional value; the cooperative skills we saw in the vocational classes generally did not develop to an effective level until after several weeks of interaction. It is interesting to note that projects in the workplace very often extend for weeks or months. Most classroom experiences do not prepare students for the problem-solving challenges posed by such long-term activities.

Authenticity was also derived from a reliance on workplace norms associated with project progress and completion. Initially, we observed more socializing going on in the classroom than one expects and thought that project progress might be suffering. But from our

assessment of the physical changes in the environment (i.e., the "found objects") over time, we learned that projects were progressing much further than we had thought. The room became progressively messier as students involved themselves in solution generation and repair.

> EXAMPLE: During the project's fifth week we observed side desks covered with rolls of paper, primarily discards with various shapes—squares, rectangles—cut and removed. We counted ten such discards, left from students' work on composing boards. Wallpaper books were open to samples. Samples were cut from design magazines. The east wall of tables was littered with seven T-squares, three sets of boards (two used and crudely cut, the third new), a box of uncut boards, and a box of tile samples with seven of 24 remaining. The bookcase of wallpaper and design books was no longer organized, as students selected materials continually. The multidrawer storage cabinet for finished products was three-quarters full; two weeks before it had been empty.

Project work in the workplace has similar dynamics. Socializing goes on until the very last minute, when the deadline crunch is near. Solution generation and repair is manifested in mock-ups, draft reports, paper piles, and messy offices. In Ms. Adams's class, evidence of this trial-and-error period could be seen in the mock display boards using plain paper and the multiple drawings of floor plans and elevations showing various degrees of detail and accuracy.

Just as a seasoned manager knows just the right criteria by which to judge project progress, Ms. Adams monitored progress by the types of questions students asked. She characterized certain types of queries as "first-week" questions: "What do I do next?" "Where can I find a pencil and tape?" She could see progress when students began to ask questions indicating their active involvement with problem solving: "Does this sketch need more shading?" "Does this mirror work as a focal point?" While Ms. Adams's approach to monitoring and her adult treatment of students gave the appearance of a "hands-off" teacher, the classroom also took on a decidedly workplace orientation akin to one in which expectations about a project's completion guide a manager's communications to, monitoring of, and intervention with adult workers.

2. Freedom in organizing projects. The way the projects were organized appeared at least as important as the project content in contributing to student learning. In these classrooms, we observed a high degree of student choice at many levels.

- *Choice of projects.* In Ms. Adams's class, projects were underdefined. While all groups were required to decorate six rooms of a house, the house itself was open to choice, as was the design of each room. In Mr. Smith's class, each project had a well-defined product, but the choice of product was up to the student.
- *No intermediate milestones.* Especially in Ms. Adams's class, once students understood the basic deliverables of the project, they were given relatively little aid in decomposing this large goal into manageable subgoals. This often led to floundering. But it also forced students to manage their own time and make decisions about how to organize or decompose large tasks.
- *Students did not proceed lockstep.* Students had surprising autonomy while working on projects. This is partly a consequence of the lack of structure that resulted from having no intermediate milestones. To further encourage students to work at their own pace, the teachers physically structured the class so that students generally knew where the required tools were and how to use them (e.g., Mr. Smith trained students to use all the important power tools at the beginning of the semester). In this way the teachers further relinquished local control on student actions, in strong contrast to the

typical practice of providing access to materials and tools through the teacher, which is a natural way to regulate and synchronize student behavior. The relaxation of teacher control also allowed, among other things, free student movement around the classroom as well as other behaviors that gave the appearance of disorder and general chaos. However, teachers apparently felt the benefits accompanying the disorder outweighed its costs.

- *Teachers resisted intervention.* Surprisingly, teachers spent little time circulating and judging student progress. Ms. Adams, for example, even at the beginning of the project when students were floundering the most, generally stayed at her desk (at the front of the class) and commented only when students asked questions. As previously discussed, the fact that teachers did not intervene did not mean they were not monitoring students.
- *Students performed different tasks and learned different skills.* Not only were students permitted to proceed at their own pace on projects, but, at least in Ms. Adams's class, they were not required to learn uniform skills. Each project required the completion of several tasks involving very different skills (e.g., doing a history of an architectural period, drawing the house elevation, selecting fabrics for rooms). Members of each group could negotiate to determine who would do each task. Hence, within limits, students could select tasks that appealed to them or for which they had talent.
- *Freedom from typical classroom rules.* Consistent with their belief that school constraints are often unnatural, teachers implicitly structured their classrooms so that at least some of the conventions of normal classrooms were abandoned. As we mentioned earlier, both Ms. Adams and Mr. Smith were skeptical of classroom rules designed to maintain order (e.g., students remaining quiet and seated). Ms. Adams consciously permitted a considerable amount of fraternizing and off-project activity in her class. This freedom was curtailed only when group members abused the privilege by falling behind in their work. In general, students were permitted to talk freely and move about the classroom as they wished.

Relationship to knowledge goals. The way the teachers structured projects is consistent with the goals set out in the previous section. In many respects, the freedom given students to organize their projects reflects th[illegible]lities of the workplace. In addition, it is consistent with teachers' interest in having students [illegible]ake their own decisions and take responsibility for those decisions. For Ms. Adams, at least, this conviction goes further. One of her main knowledge goals was to help students learn to be bold in decision making or to be creative. Central to her model of how to engender creativity was to put minimal constraints on students' thinking.

While organizing projects in an unconstrained fashion is consistent with imparting certain important skills and attitudes, it has potential drawbacks. In particular, in both classrooms we observed behavior that bordered on chaos and floundering. In giving students the freedom to organize their activities there is a real danger that they will dissolve into disorganization. Below we discuss some of the techniques the teachers used to prevent this, and we also discuss what happened when they failed to prevent it.

The Role of Teacher Policies

The teachers had several broad rules of thumb or policies that seemed to govern in a global way how they informed and interacted with students. These policies often complemented features of the projects and helped to enhance the value of the projects in supporting learning.

1. Teacher and student on an "equal" footing. Many observations suggested that teachers strove to interact with students "on their level," or perhaps to elevate students to the teacher's level. This was most easily seen in the casual friendliness and respectfulness of teacher-student interactions. For example, Mr. Smith's students often called him by his last name only; Ms. Adams and her students frequently spent the minutes before and after class in social conversation. Ms. Adams's rapport with her students was evident during our interview with her at the end of the semester—several students stopped by to get their grades, discuss problems they were having with other teachers, and chat about the senior class party. The existence of this common level was clearly understood explicitly by the teachers, and perhaps more implicitly by the students. Our discussions with students revealed that they sensed genuine caring and respect from the teachers. Ms. Adams, for example, is aware, and chagrined, that many teachers have a low opinion of their students. In contrast, her view is very positive:

> There are many issues outside of teaching that are important in the school. I am just amazed at the problems these kids have while they are still taking classes. And they pull it off. How can you look down on these kids when they do all of that? Could you do it? I couldn't when I was that age.

Relationship to knowledge goals. Our observations suggest this common level served several important functions. Most obviously, it improved student-teacher relationships. Generally, teachers find it easier to teach students who like and admire them and who feel that the respect is mutual. Second, it is consistent with the teachers' attempts to disengage the classroom from usual academic conventions. Among these conventions is a view that students are in some sense inferior to teachers, at least in knowledge and experience. Third, the common-level approach is consistent with the teachers' attempts to reduce their authority (at least with respect to providing the sole standard of judgment) and to instill students with a sense of independence. Finally, the positive relationship between students and teacher provided an environment in which students could make decisions without fear of failure, as we elaborate below.

2. Master-apprentice relationship more than student-teacher. Broadly, the kind of relationship we observed arising between student and teacher was neither the usual student-teacher relationship nor a strictly collegial one. Rather, in some respects it resembled the roles of master and apprentice.[2] The teacher was regarded as the expert or "model" practitioner of the craft, and he or she also possessed a greater associated factual knowledge and skill. On the other hand, the student had a limited knowledge of facts and skill but was increasing both continually.

Both Ms. Adams and Mr. Smith were competent lecturers but placed little emphasis on this way of communicating information. Mr. Smith's lectures were usually quite brief, and they appeared to be the least interesting part of each class for both teacher and students. He explained that lectures were kept brief because they usually involved demonstrating procedures. Ideally, such lectures came just before students were ready to use the procedures. However, since Mr. Smith's students did not progress in unison, many students forgot the lectured information by the time it was needed.

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[2]The features that constitute a master-apprentice relationship have been the subject of much recent debate (e.g., Collins, Brown, and Newman, 1989). In particular, the extent to which "ideal" masters give information about student performance is unclear. Thus, one might argue that many masters would provide more feedback and correction than did our teachers. In later sections we evaluate teacher decision making in more detail.

One-on-one tutoring or master-apprentice interactions were the main methods by which teachers distributed information and shaped the students' progress. While a considerable amount of Ms. Adams's class time was spent at her desk at the front of the class, she would also circulate and interact at least once with every group. When students were still at the novice level, typically during the early stages of the project, her interactions might be either motivational or managerial in intent.

> EXAMPLE: Dave, a second-semester student working independently on his project, asks Ms. Adams about his next step. (According to Ms. Adams, this was a "first-week" question.) She replies quite sharply, giving him the answer and then continuing with the admonishment, "I'm raising my voice to you, Dave, because you ought to know this information. You had this last semester." Dave just blandly returns her look and asks, "So what is the next step?" Ms. Adams replies with exasperation, "DAVE!"

However, as groups journeyed from requiring management, through requesting merely technical information, and finally to asking for artistic consultation, the perceived quality of the interactions improved.

> EXAMPLE: Ms. Adams only approached this group once today, although she made several trips to other groups. In dealing with this advanced group, she conversed at a very high level and about domain-specific issues. For example, it wasn't in terms of "How's your decision making going?" or even "Let's see what you've chosen for the entranceway," but rather "Use Louis XIV, maybe Georgian, definitely not Colonial or Louis XV." She made no comment whatsoever on what the students had done, but just offered advice of this sort.

Ms. Adams was skilled at giving constructive local critiques of designs and at dispensing important pieces of information on request. While her lectures were invariably interesting, they focused primarily on factual information (e.g., properties of a wide range of fabrics). This sort of information was important in students' projects, as, for example, they needed to know facts about certain fabrics in order to make selections and then justify them later. However, much of the information students needed was procedural, such as how to cut matte boards or mount fabric. Virtually all this procedural knowledge was transmitted in tutorial or master-apprentice interactions. Indeed, we noted many cases where Ms. Adams simply forgot to communicate information while lecturing and distributed it later in one-on-one interactions. In general, her teaching seemed more opportunistic than planned, a style she seemed to prefer over a didactic approach following a strict lesson plan (cf. McArthur, Stasz, and Zmuidzinas, 1990).

Relationship to knowledge goals. The master-apprentice or one-on-one tutoring policy was essential because the students did not proceed in unison and their needs for information and coaching differed greatly. In some cases, the teachers' solution to this problem was to repeat the information in one-on-one tutoring interactions as students needed it. An important alternative technique used by both teachers was to delegate this responsibility to other students who had mastered the procedure in question. As with other master-apprentice situations, there is no discrete distinction between student and teacher, but rather a continuous gradation of expertise from low to high. Both teachers took advantage of this gradation by encouraging more advanced students to help less advanced ones. This solution had several important side benefits with respect to the teachers' knowledge goals. Not only did apprenticeship reduce the burden on the teacher, it also encouraged student cooperation, acted as a motivator or reward

for the student giving the advice, and freed students from dependence on the teacher's authority.

3. Adult learning model. Much of the teachers' behavior, especially Ms. Adams's, can be accounted for by their explicit view that students are mature, reasonably experienced, and motivated to learn. Several observations are consistent with this hypothesis. Most of Ms. Adams's teaching experience has been in adult vocational education and training classes, which are often project-centered. Second, in many adult education classes, the introduction and motivation for projects is brief. This is consistent with our observation that teachers minimized lecture time, often preferring to distribute information on an as-needed basis when students were solving project problems. Third, and consistent with the constrained introduction and management of projects, paperwork is also often minimized. We noted that students were given surprisingly little "hardcopy" information. For example, in Ms. Adams's class, students were not given a written description of the main deliverables of their projects, even though there were several well-defined tasks that needed to be accomplished.

Relationship to knowledge goals. We observed several ways in which this adult learning model worked well for the students. In the most general sense, it promoted an egalitarian atmosphere in class, consistent with the teacher's desire to raise the "level" of the students. In addition, it permitted greater time-on-task in projects and enabled teachers to focus their teaching efforts more on "micro-apprenticeships" than on lectures, which could not be tailored to the needs of individual students. However, we also noticed several potentially undesirable effects of this approach to teaching, which we detail later on.

4. Class projects as business; accountability. Throughout project work, the teachers continually shaped students' learning and performance by relating aspects of the project to the workplace. In Ms. Adams's class, projects were initially motivated by their relationship to external factors. Ms. Adams made it clear to students that the project activities they were engaged in simulated the tasks of real designers. Students were also made aware that performing well in the class had some more immediate real-world benefits: local stores often hired students who completed this course; previous students in the class had gone on to win design competitions. Thus, in several ways, her students understood that their projects were not simply academic exercises.

During the course of projects both Ms. Adams and Mr. Smith justified many of their decisions by citing their authentic relationship to workplace contingencies. For example, as noted above, Mr. Smith would usually resist giving answers to students, instead asking them what would happen if he were unavailable. Mr. Smith frequently used business metaphors in discussing how students will be judged: "If you don't work, you won't get paid"—that is, the student's grade will suffer. For Ms. Adams, relating consequences of student behavior to workplace contingencies is second nature, as she said in her interview (see "Knowledge Goals" in Sec. IV, part 4d).

Mr. Smith not only discussed students' performance in terms of the workplace, but in several ways actually violated conventions to transform the classroom into a workplace.

> EXAMPLE: At the beginning of class, students cheerfully arm themselves with their brooms and dustpans and police the campus and pergola area, then return to class for their "reward" (grilled cheese sandwiches). This practice has been especially arranged by Mr. Smith and is, strictly speaking, against school rules, since students are not supposed to be in the yard during class time.

Mr. Smith explained that the sandwiches are distributed as part of the school nutrition program, and those that remain uneaten get thrown away. Thus, he "made a deal" with the food concessioner at the school to give the sandwiches to him in exchange for his students' cleaning up the lunch area. The janitor, of course, is also happy with this arrangement.

> EXAMPLE: Mr. Smith asks for a volunteer, selects a student (usually one that is far along on his/her project), and has the student help with some specific task. In one case the student helped make dustpans for the yard-cleaning activity and for shop cleaning. Once Mr. Smith had completed spot-welding, he folded the precut sheet metal while the student helped hold the metal down. Mr. Smith spoke to the student and gave pointers throughout.

These tactics are true "multipurpose moves" that serve to further Mr. Smith's goals. They tie the classroom to authentic workplace situations, model the ideas of looking beyond form to function and questioning authority (the first example), and represent classic master-apprentice interactions (the second example). Moreover, they provide his students with meals (many of them are from poor families and may come to school hungry) and, finally, provide Mr. Smith with useful shop tools.

Although the workplace perspective aims at making students accountable for their work, teachers are careful to temper the hard line this implies when it might jeopardize student motivation.

> EXAMPLE: The class is almost over (Mr. Smith had called for cleanup), but one girl is not quite through sawing a wedge off her hammerhead. He just stops and completes it for her. In doing this Mr. Smith makes an obvious exception to his rule of insisting the students solve problems themselves and not appeal to authority. Apparently he felt that completing this goal at this particular time was very important.

> EXAMPLE: Linda and Rose nervously seek out Ms. Adams's assistance on their project, since both Stan and Anna (an exchange student who returned home) have left the group. Ms. Adams tells them not to write Stan off yet, and she promises that she will assign another student to help them with the art work if he does not return. She recruits Frank as the backup, promising him extra credit for the work.

Thus, these teachers appeared to understand the pedagogical limitations of strictly viewing the classroom as a workplace.

The Role of Specific Teaching Techniques

Teachers employed specific teaching techniques to implement their knowledge goals and policies. In the above discussion of different policies we had occasion to describe several techniques used in their service. Here we attempt to understand the specific techniques employed by the teachers to solve some of the problems that arise in a project-centered classroom where students are given considerable freedom and are taught using an adult learning model. The main challenge was to keep students on-task without obviously constraining their problem solving.

1. Techniques for encouraging boldness and independence—a "fail-soft" environment. Teachers recognized that students would not be willing to make bold, independent decisions in a typical classroom environment, which harshly penalizes the failures that inevitably result. Several teacher techniques insured that students did not regard failure as undesirable.

- *Attempts at creative solutions held intrinsically desirable.* Ms. Adams, in particular, made it very clear to her students that the act of trying unusual design combinations would be rewarded regardless of the quality of the result. During the interview, she confirmed that some students with "objectively" poor projects could get high grades if they had shown attempts at creative thinking and consistent attention to the task at hand.
- *Refraining from correcting errors.* Teachers often did not correct student errors. As we discussed above, Mr. Smith's teaching philosophy viewed errors as useful learning situations. Ms. Adams's philosophy was that correcting errors threatened students' creativity. She noted that instead of correcting what she felt were dubious design decisions, she preferred to take a more constructive approach by providing alternatives to the students' proposals.
- *Negative feedback without negative affect.* Even though the teachers encouraged creative efforts, they sometimes judged the results critically. Moreover, Ms. Adams and Mr. Smith were exceptionally gifted in being able to communicate negative information without threatening students. While Mr. Smith was often quite gruff with students, and Ms. Adams frequently laughed at (or perhaps with) students, both teachers carefully structured their relationships so that students were rarely threatened by the teacher's honest appraisal. The students appeared to understand that criticism did not mean a loss of respect or caring.
- *Constructive use of failures.* Both teachers were able to turn failed attempts at problem solution into positive learning experiences.

EXAMPLE: In Ms. Adams's class, one of the more advanced groups forgot to do a major part of the project. Ms. Adams makes this omission clear. She comments that on the review sheet (every student must fill out a review sheet in which they critique the successes and failures of their project and group) their task is to figure out what happened and to "try to figure out why no one is to blame."

In information-processing terms, the teachers were supporting and encouraging students' attempts to generate many solution paths in confronting a problem. Perhaps more importantly, they were demonstrating that failed solution paths might be repaired and they were modeling techniques for repair that use the information gathered from failed paths.

2. Techniques for dealing with students who are not proceeding in unison. One of the major challenges facing the teachers was the problem of dealing with students who are often simultaneously engaging in very different tasks. How can the teacher be sure the students are on-task and productive? The teachers appeared to use several tools or tactics:

- *Motivation and responsibility.* Especially in Mr. Smith's class, we found that very few students were attempting to avoid working. Motivated students generally require relatively little minute-to-minute monitoring. Ms. Adams monitored progress by evaluating the types of questions being asked.
- *Grading.* As in most classes, final grades appeared to be an important tool in keeping the students on-task. However, grades are effective in keeping students on-task only to the extent that students find them meaningful. Either because the projects were intrinsically valued by the students, or for extrinsic reasons (to please the teacher, to graduate, etc.), grades were generally important to these students.

- *Group management skills.* While the teachers let students try things out their own way and make mistakes, both seemed to have excellent monitoring and diagnosis abilities. They could rapidly scan a class and determine when a student's mistake had gone too far. Then the teachers would intervene, often orchestrating the encounter at a distance.

EXAMPLE: At the beginning of class, several students try to drill holes. They aren't making much progress, and, since Mr. Smith has his back turned and is occupied with other work, this is likely to continue. Suddenly, Mr. Smith yells from across the room, telling Tomas that something is wrong with the way he is setting up the drill. He explains the problem briefly, Tomas begins again, and Mr. Smith goes back to his own work.

- *Apprenticeship and micro-teaching techniques.* As we noted above, teachers accepted the need to repeat information frequently to students and turned that burden into a benefit by delegating authority to students who had already been tutored.

EXAMPLE: Working on the floor plan, a frustrated student tells Ms. Adams, "I've tried this three different ways, and can't get it right. What is most easy?" She suggests that he talk to Sam, whom she had previously tutored through the floor plan sketch. The two students work together for nearly ten minutes and successfully move the project along.

3. Techniques for dealing with students who are solving ill-defined problems. Especially in Ms. Adams's class, a major challenge for the teacher (and the students) was that students were dealing with ill-defined problems as well as progressing at different rates. Because the students were not familiar with such "open" problems, we observed a great deal of floundering and low productivity in the early stages of the project.

EXAMPLE: A group looks through magazines to select pieces of furniture for a room. After about 10 minutes, only one student is holding up pictures, while the rest of the group gives yes/no responses. There is one generator and three testers. One student leaves the class for points unknown. A few minutes later the student slows his pace of generating examples, and the others, bored with waiting, look around, watch the class, but do not communicate. Finally, one picks up a magazine and asks "What do we do now?"

Scenarios such as these were typical, and they explain how a given group might spend an entire class selecting one piece of fabric. Ms. Adams used several of the techniques noted above to guide students and reduce unproductive behavior. In particular, micro-teaching and apprenticeship tactics were essential in modeling how to select fabrics and furniture. Ms. Adams also expected the students to be relatively self-reliant and motivated.

However, Ms. Adams refrained from taking several obvious actions that might make the problem more well defined. For example, although some aspects of the project were inherently ill defined or creative (e.g., the tasks of selecting and combining fabrics and furniture in designing a room), many project deliverables were actually well defined. Students were required to do boards for six rooms, draw floor plans and an elevation, and write a history of the architectural period of their house. Yet, the details of these deliverables were not clear to students (or the researchers) until very late in the project. This ambiguity had frustrated students. For example, when told that they would need to do six rooms for the final project (approximately two weeks before the project was due, four weeks after it was begun), most students, including groups who were the most advanced and organized, were caught by surprise.

An obvious tactic Ms. Adams could have used was to clearly define project deliverables and constraints in introductory lectures, accompanied by hand-outs outlining project requirements. Her decision not to use such constraining techniques appears to follow from her general model of problem solving (at least for interior design, but not necessarily limited to this), in which the "creative process" is given center stage. She apparently believed that giving students more detailed project requirements would threaten their creative reasoning and interfere with boldness in decision making. She was aware that students flounder considerably as a result but was willing to accept a high level of "noise" early in the project in return for interesting ideas later. Mr. Smith was also willing to accept this cost:

> EXAMPLE: One girl spent a lot of time buffing her hammerhead to a shine before (rather than after) she filed it down. In addition, whereas files only cut on the forward stroke and work best at a specific angle, students scrubbed away on both strokes and at random angles. There was little attention to optimizing labor or tool use.

Costs and Benefits of Teaching Policies and Techniques

Overall, our observations indicate that both Ms. Adams and Mr. Smith adopt a "hands-off" policy in controlling student learning. They prefer to help students learn through induction and discovery rather than to teach didactically and directly. Of course, along with its potential benefits, this strategy is not without its costs, some of which we have enumerated. In many specific contexts, the teachers are aware of these costs, exemplified by Mr. Smith's allowing students to file forward and backward when he obviously knew it was wrong. Moreover, both teachers appear to have a general understanding of the inefficiencies of undirected learning. But by word and by action they indicate they are willing to accept this potentially high cost in exchange for benefits measured primarily in terms of dispositions and beliefs students acquire when given great responsibility for their own learning.

It is difficult to determine whether the benefits of a hands-off teaching policy outweigh the costs. Part of this difficulty certainly stems from the subjective nature of those costs and benefits. These teachers value the benefits highly, while other teachers may place a much greater premium on domain-specific knowledge and generic problem-solving skills than on dispositions and beliefs. Even so, as we indicated in the last section, we observed teaching techniques that appeared to actually inhibit the teachers' goals. In particular, it is a common misconception (shared not only by our teachers but perhaps much more widely) that organizing tasks carefully and giving students clear constraints and goal structures are incompatible with permitting them freedom on open or ill-defined tasks. The literature on problem solving illustrates several techniques for structuring open tasks, avoiding some of their potential costs in terms of floundering but still maintaining their benefits.[3]

In summary, it is possible to evaluate the teachers' educational policies and techniques for implementing them at two levels. First, we might take issue with their general choice of an open, discovery-oriented environment as opposed to a more didactic classroom structure. However, there is little literature in education or cognitive science that allows us to decisively favor

[3]A cognitive science model of problem solving, for example, provides one alternate approach to those we observed. It suggests that a good learning environment for an ill-defined task (like interior design) should not be completely ill defined (Polya, 1980; Schoenfeld, 1987). Particularly when the task is difficult, the best learning environment is one that clearly bounds the ill-defined or creative parts. For example, although the process of choosing fabrics, furniture, and wallpaper for a house is open-ended and should not be reduced to an algorithm, the components of the project—what rooms the students need to finish, what schedules need to be filled out to complete the task, and so on—might be very well defined.

one option over the other, especially considering the subjectivity of the costs and benefits of both. Second, we might take issue with how the teachers implemented their hands-off policy. At this level, we can point to specific tactics the teachers might have used to further their goals. On the other hand, our analysis also shows that many of their tactics appeared very effective. For example, the teachers' techniques for controlling chaos can be viewed as generally creative solutions to difficult teaching problems. Overall, both Ms. Adams and Mr. Smith have a rich intuitive understanding of adaptive problem-solving techniques that cognitive science has only recently begun to formalize.

Student Techniques and Adaptation

Having examined how the teachers' policies and techniques have shaped the learning environment, we now turn to students' responses to this environment. Below, we briefly examine student behavior, focusing primarily on how students adapted to the unconstrained problem-solving environment in Ms. Adams's interior design class.

The student groups appeared to have different ways of adapting to the ill-defined nature of the project and to the floundering that resulted, which we shall examine shortly. As the project progressed, groups gradually became more focused, and students defined relatively stable roles for themselves. In some cases, the students appeared to spend as much problem-solving energy and time establishing routines for dealing with uncertainty as in thinking creatively about how to coordinate furniture and fabrics. Of course, this is not necessarily inconsistent with the teacher's knowledge goals described above. Indeed, Ms. Adams expected it would take at least a week for most groups to begin to perform and ask meaningful questions (e.g., "Does this fabric go with the mood of the room?" as opposed to "Where do we find the furniture books?").

In some cases we observed "the rich getting richer," a consequence of the openness of the projects, the adult learning policy of the teacher, and her willingness to start at the student's experience and interest level. The students in some of the more advanced groups already possessed several of the important skills of adult learners and thus needed to spend less energy on management activities; hence they devoted more time to acquiring and tuning design skills. Moreover, Ms. Adams was a better resource for students who had reached this stage than for students who were less advanced. She acted as a good consultant for groups engaged in design-related decisions, but she was less effective as a coach for groups still grappling with basic technical and organizational difficulties. For many of these groups, progress on the project was exceedingly slow. Tasks remained ill defined for long periods of time, motivation appeared low, and cooperation limited. The literature suggests that we might view the students who flourished as "mastery-oriented" and those who did not as "helpless-oriented" (Dweck and Leggett, 1988). While this may be true to some extent, it is also the case that some of the students simply had skills that permitted them to negotiate this challenging environment and others did not, although they persisted. At any rate, we did not measure students' learning orientation in this study and thus cannot determine its influence here.

Below, we itemize several of the tactics groups used to organize the unconstrained environment in which they were placed. To some extent, all of the tactics are creative and adaptive. On the other hand, we believe that some of the responses at least partly subverted the teacher's intentions. That is, these tactics permitted students to accomplish *their* main goal (completing the project) without requiring them to meet the teacher's intended knowledge goals.

1. Offloading. When confronted by the open-ended task of selecting items to decorate rooms, many students initially appeared to have no idea of the aesthetic criteria to use to constrain their decision making. Instead of coming to grips with these criteria, several of the bolder students adopted the tactic of making an apparently random selection and showing it to Ms. Adams. If she approved it, their problem was solved; if she didn't (which was usually the case), she often redefined the task to be much more constrained.

> EXAMPLE: *Tim*: (Pulling out the same wallpaper sample as before) How does that work in this bedroom? *Ms. Adams*: (laughing) Not too good. *Tim*: (laughing) I didn't think so, but I thought I'd ask first. *Ms. Adams*: You've only looked at English chinty, which has a delicate look. Look for some other chinty that would work for the mood of your room. *Tim*: (walking away) Thanks. (Upon his return to the group, they "celebrate" his getting the "right answer out of her.")

2. Bulldozing. In some cases, students skirted the issue of coming to grips with artistic questions using even more "brute-force" techniques. As with offloading, the students would make a quick selection. But instead of consulting Ms. Adams, they would simply incorporate it without further decision making. In some cases students attempted to use whole rooms cut from magazines; however, Ms. Adams always caught this tactic.

> EXAMPLE: Rich provides design assistance to Dave: "That carpet is ugly with that wallpaper, man. Who's gonna hire you?" Dave laughs about this and goes off, coming back a few minutes later with a new carpet sample. They do not discuss the merits of this new item.

> EXAMPLE: Alan shows Ms. Adams his living room. It is a full-page picture cut from a magazine. Ms. Adams explains that he must design each room himself, not take the magazine's design. She suggests that he take a sofa or chair or lamp for inspiration and build around that. Alan quietly returns to his seat and, asking for scissors, begins cutting from the picture. He also has a full-page picture of a kitchen.

Generally, students adopting this technique appear to be trying to find the minimal requirements for completing the project and satisfying them with as little effort as possible.

3. Development of different cooperative styles. Through the course of the project we observed all groups cooperating as a means of dealing with the unconstrained environment. One of the more advanced groups comprised members who had already worked together (in a previous semester), and their cooperative skills were good from the beginning. They had already determined their roles: one student was the "workhorse," willing to go through magazines to generate alternatives; another the "judge," whose artistic tastes were the most well respected; and a third the "coordinator," willing to present ideas to Ms. Adams and report her feedback to the group. These roles generally remained stable throughout the project. However, most groups had not worked together before and spent several weeks negotiating stable roles. In most cases, the cooperative styles that evolved did not appear to be as succesaful as the ideal described above. Alternative styles we observed included:

- *Military*. After some initial controversy one student emerged as the leader, although he or she did not appear to have the full support of the group. Consequently, the leader did most of the project tasks, and those that were delegated were usually not accomplished cooperatively.

- *Loose anarchy.* A "de facto" leader emerged, but otherwise cooperative roles were not well defined. Frequently in this group at least one of the members contributed minimally. Perhaps surprisingly, students rarely used peer pressure to control noncontributing members. Ms. Adams also never suggested this strategy.
- *Lone wolf.* Two students decided from the beginning that they would rather do the project alone rather than as a member of a group. They both felt that working with a group was more of a hindrance than a help (one "just wanted to finish up," while the other "didn't want those people thinking they are doing my work for me"). Interestingly, these students evolved a useful cooperative relationship while still completing individual projects. One of the students was a major success story. He began the project as a "bulldozer," unwilling to confront artistic decision making. By the end of the project, according to Ms. Adams, he had discarded all his initial selections in favor of much more reasoned ones.

Social Learning Theory Interpretations of Teacher and Student Actions

While we have been viewing teacher behavior primarily from an information processing perspective, the perspective of social learning theory is also illuminating. For example, it appears possible to explain many of the teachers' general attitudes, policies, and specific techniques in terms of Dweck and Leggett's (1988) process model. We find evidence for the "mastery" orientation at each of the model's levels. At the most abstract level, the teachers clearly believe that things can change. In Dweck and Leggett's terms, they do not hold an "entity" theory of intelligence, and, generally, they believe that desirable qualities can be cultivated. Perhaps more importantly, they communicate this belief to their students by emphasizing boldness and accountability. Consistent with this belief, the teachers generally also appear to encourage students to focus more on learning goals than on performance goals. Many of the specific techniques we reviewed can be seen as attempts to promote learning over performance: making grades contingent on relative changes in a student's competence as opposed to meeting some uniform performance level; promoting development over judgment; and providing a fail-soft environment in which mistakes are not discouraged. Overall then, we can view the teachers as attempting to provide an environment that convinces students that the world is changeable, not fixed and beyond their control, and that learning is a key to change.

Looking at student cognition, affect, and behavior, we can see some evidence that teacher strategies and techniques may have helped move students from a "helpless" to a "mastery" orientation. In particular, the actions of several of the "lone wolf" students in Ms. Adams's class show a strong change in this direction. At the beginning of the project, these students engaged in much task-irrelevant behavior, perhaps rationalizing their anticipated poor performance by indicating a general disinterest in the class. By the end of the project, several of the lone wolves were clearly engaged in extensive solution-oriented self-instruction, and in interviews they offered much more positive views of the course.

Students' Opinions about Generic Skills

On the day we distributed the student questionnaire in Ms. Adams's class, 18 students attended class and 15 (11 female and 4 male) completed the questionnaire. Most of the students were seniors who had taken about two vocational education classes on average.

An examination of the students' class schedules for that semester revealed a wide diversity in course loads and academic-laden versus nonacademic-laden schedules. This diversity was echoed in the responses to a question about future educational plans: Six students reported that they would be attending a junior college, with one of the six planning to major in interior design. The others planned to attend a four-year college or university. Students' reasons for enrolling in the class included interest in the domain (N = 5), the reputation of the course among counselors and friends (N = 6), and to fulfill the district fine arts requirement (N = 2).

Student ratings of course content (on a four-point scale where 1 = strongly disagree and 4 = strongly agree) are presented in Table 2. Students generally agreed that the generic skills emphasized by Ms. Adams were valuable. Two skills in particular, cooperating as part of a group to achieve a goal and justifying one's opinions with facts, appear to be highly valued. These were skills in which Ms. Adams explicitly provided practice and that she repeatedly emphasized in her interactions with students during the course of the final project.

EXTERNAL FACTORS THAT SHAPED THE LEARNING ENVIRONMENTS

Many different kinds of factors can shape and influence what goes on in schools (cf. Barr and Dreeben, 1983). While we can't often link these characteristics directly to student learning or persistence in school, we do know that they can either enable or constrain classroom teaching and learning (Oakes, 1989). John Goodlad (1984) uses the term "commonplaces" to refer to the descriptive variables found in all school systems whose range of values produce the

Table 2

STUDENTS' OPINIONS ABOUT GENERIC SKILLS

Item	Percent Responding					
	Strongly Disagree	Dis-agree	Agree	Strongly Agree	Mean	SD
I learn a lot from the teacher's lectures.			53.3	46.7	3.47	.51
I'll use knowledge from this class in future jobs I get.		13.3	66.7	20.0	3.07	.59
It's important to learn to work in a group.			40.0	60.0	3.60	.51
Group work is better than individual work for doing problems in this class.	13.3		40.0	40.0	3.14	1.03
This class has helped me become more creative in my thinking.	6.7	6.7	46.7	40.0	3.20	.86
Learning to work with others is an important job skill.			26.7	73.3	3.73	.45
It's important to back up your opinion with facts.			40.0	60.0	3.60	.51
I have learned how to communicate with people better because of this class.		26.7	60.0	13.3	2.87	.64
If I have a choice between working alone or with others, I'd rather work alone.	6.7	53.3	33.3	6.67	2.40	.74
Working as a group and getting a group grade on projects is fair and a good way to work.		46.7	40.0	13.3	2.67	.72

NOTE: N = 15 for all items except the fourth, where N = 14.

observable differences between systems. These commonplaces include: educational objectives, curriculum guidelines, textbooks and materials, teachers and their knowledge capital, staff development, student assignment, resource and time allocation, testing, school organization, and incentives. In the case of vocational education, other external factors may also impinge, particularly demands from the workplace concerning the kinds of skills workers need. In addition, context information provides clues to policymakers about why schools get the outcomes they do. Measuring or understanding what goes on in schools can add important information to discussions about how to improve them (Oakes, 1989).

Since it was beyond the scope of this exploratory study to examine all these commonplace variables, we focused our data gathering to understand the factors that might affect instructional practices in the interior design class (previously discussed in Sec. III). In particular, since Ms. Adams taught within the Regional Occupational Program, we gathered information on the organization and mission of that program by interviewing the local ROP administrator. We also interviewed a local employer who hired students from Ms. Adams's class, to get his perspective on the kinds of skills needed in the workplace. Finally, we interviewed Ms. Adams herself, to gain her perspective on teaching generic skills, her educational philosophy, and so on.

Considering all these perspectives, we concluded that two key factors shaped instruction: teacher autonomy and the teacher's educational philosophy. While school and ROP organizational policies and practices highly affect the former, they have little direct impact on the attitudes that the teacher brings to the classroom. We discuss our interview results and elaborate on these findings below. This discussion is intended to provide the context for one classroom and to suggest hypotheses about the effects of context on teaching that can be addressed in future work.

The Regional Occupational Program

The Regional Occupational Program (ROP) is a state agency administered by the California Department of Education and implemented through county offices. The ROP offers entry-level job training for local job markets where the entry wage is above minimum wage. In addition to the goal of providing entry employment skills training, the ROP's mission extends to career exploration opportunities and preparation for higher education in a related skill.

In practice, this mission promotes several differences between ROP classes and those traditionally offered in secondary school vocational programs. First, since the ROP intends to provide both job training and preparation for postsecondary education or training, a more diverse group of students enrolls in and is served by these classes. Traditional vocational education classes in many secondary schools essentially "track" students not bound for college (Oakes, 1986). Second, the ROP hires instructors who have had recent working experience in the areas they teach. Many secondary-level vocational programs do not require such work experience for teachers. Finally, the ROP communicates regularly with local employers to determine skill needs and market opportunities for its students; few vocational programs do so.

The ROP interior design class was taught at a comprehensive secondary school that included its own vocational education courses and programs. Students attending the school could enroll in academic, vocational, and ROP classes. Administration of the ROP classes is largely separate from all others at the school. The ROP administrative office is far removed from the school's office; it maintains its own teaching and counseling staff. However, some coordination between the local ROP office and the school administration was required. In this

comprehensive school, it seemed that the ROP classes were designated as part of the school's vocational offerings, which held a subordinate position overall in its priorities. Vocational education's lower status was evident, for example, in the fact that vocational education concerns were fragmented over several vice principals.[4] As a second example, evening and weekend vocational classes are officially designated as "period seven" because recordkeeping is designed for a daytime school schedule of six periods.

While the ROP is administered by a statewide agency, local school programs have a great deal of autonomy over curriculum content. The reasoning is that industry teachers will be highly attuned to workplace demands and changes and should therefore have the flexibility to maintain program relevance to the workplace. Although teachers are required to cover a list of state competencies, they are permitted to determine the approach and focus of their courses.

ROP administrators and teachers are not immune to local conditions that can threaten this autonomy. Several years ago, for example, the local school district made major policy changes in curriculum and graduation requirements in response to statewide secondary education reforms. The new requirements left little time for elective courses, and as a result, enrollment in vocational classes (including ROP classes) and other electives (e.g., foreign language) suffered. Since enrollment can affect funding allocations, the local ROP administrator and others reviewed the vocational courses in the school to identify those whose content was consistent with required courses. As a result, several ROP courses fulfill district graduation requirements: interior design for fine arts; accounting for math; and entrepreneurship for economics.[5] This change assured high enrollments for the interior design course. We met a number of students who had in fact enrolled to fulfill the graduation requirement.[6] The high enrollment in the interior design class, coupled with additional funds allocated to ROP classes, meant that Ms. Adams had a larger budget than most vocational classes at the same school. Resources such as a program's budget can affect the quality of the educational program provided (Oakes, 1989). According to Ms. Adams, her budget enabled her to support large projects like the house design. We observed that students had a wide variety of professional materials at their disposal, including architecture and design magazines and books, wallcovering and floorcovering samples, and mounting boards. Thus, students were able to design their project houses "from scratch," with materials similar to those used by professional designers.

Although the ROP response to district policy increased enrollments and enhanced Ms. Adams's ability to provide quality instruction, it might also yet compromise teacher control over course content. That is, if an ROP class's survival depends on its resemblance to an "academic equivalent," it could begin to lose its "schooling for work" focus. At the time of our interview, we did not determine to what extent "equivalent" course requirements might affect future ROP course content.

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[4]Other schools administer vocational and academic programs quite differently. A neighboring school district, for example, has a districtwide vocational education administrator in addition to one at each high school.

[5]Interestingly, the ROP administrator credits the fine arts graduation requirement to one arts "champion" on the school board. Thus, although interior design currently fulfills a fine arts graduation requirement, the future status of this arrangement is highly uncertain. In addition, while this "cross-crediting" is not uncommon, it is not the norm for this state. The state is inclined to view requests for such credit as attempts to dilute the impact of raised academic requirements.

[6]While completion of the interior design course was required for some students to graduate, several told us that the grade they received was unimportant. Although that grade is included in their overall grade-point average (GPA), it is *not* calculated in the GPA used for college application. This practice created a disincentive for some students to do well on the final project.

Teacher Autonomy

Teachers in the vocational classrooms we visited seemed to have a great deal of autonomy with respect to what they taught and how they evaluated their students. This was particularly true for Ms. Adams. In comparison to teachers of academic classes in the same school, Ms. Adams had great freedom in designing her course. She did not have to use a state-mandated textbook or prepare her students for standardized examinations required by the state or for college entrance. Nor was she concerned about preparing students to take particular advanced courses in the same subject area.[7] All of these factors suggest that the interior design curriculum had fewer domain-specific knowledge and skill requirements, relative to many academic courses. Thus Ms. Adams was free to develop a course that stressed generic skills over domain-specific skills. Furthermore, her choice of generic-skill knowledge goals was based primarily on her own experience of what interior designers needed to know. She kept this knowledge up-to-date by doing part-time professional design jobs and participating in professional organizations.

Our interview with a local employer corroborated the wisdom of Ms. Adams's curriculum content decisions. This local retail store manager provided a 16-hour work experience program for second-semester students in vocational programs, including Ms. Adams's interior design class. He felt that entry-level interior design jobs require both domain-specific knowledge and domain-general skills. The manager stated that while the company values an employee's art skills, he personally values a background in design work equally with

> a personality that is outgoing and shows evidence of broad interests. . . . This is going to be someone who will mix well with people and will be free to show [his or her] creativity.

According to the manager, he allows employees to design displays on their own and to use their own ideas. The domain-specific portions of the job are learned through any number of art courses that build on the "talented individual, someone with an eye for color and design." Thus, his current workforce has a diverse background and includes a professional paste-up artist, a painter, a musician enrolled in a fine arts college program, and a carpenter. Because this group is required to "work as a crew," the manager also views cooperation and responsibility as highly important.

In addition to preparing students for work experience and, in some cases, actual employment, Ms. Adams was able to develop a curriculum that prepared students for advanced classwork in art, architecture, and related fields. The ROP maintained data on student employment and advanced education, and the administrator gave Ms. Adams high marks for her students' success in these areas.[8]

Other evidence of teacher autonomy stems from these vocational teachers' assessment and evaluation practices. Much has been said and written about how standardized testing drives educational policy and forces academic teachers to "teach to the test."[9] As discussed earlier, neither Ms. Adams nor Mr. Smith geared their teaching toward such tests, nor did they

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[7]For a disturbing view of mathematics teachers' limited autonomy see L. V. Morris (1989).

[8]The county conducts follow-up surveys to determine student employment as a function of ROP enrollment. If placement drops below 35 percent, the program goes on probation (although classes can continue). When this happened to a high school television production course, the county took exception to the rule because course graduates were prime candidates for local university film schools. The ROP now considers preparation for postsecondary education equally acceptable with job placement as a means for measuring program outcomes.

[9]Koretz (1988), for example, cites several concerns about standardized testing practices: the school curriculum narrows, with less time devoted to subject areas not covered by exams; the range and depth of teaching *within* a subject area similarly narrows; instruction focuses on types of tasks represented in tests, at the expense of others—e.g., multiple-choice over essay formats.

expect uniform performance from their students. Ms. Adams tells beginning students that they have an "average taste in design" and thus come to class as "C" students; to get a higher grade, they need to learn something. Since many types of expertise are valued in the design field—color sense, artistic ability, art history, planning—students can show growth in any one of several areas. She evaluates students by gauging them at the beginning of class and determining if and how much progress they make in their chosen area.

Ms. Adams's evaluation and assessment practices may also be a by-product of benign neglect. According to the ROP administrator, vocational and ROP classes in this school suffer from the widespread view that "vocational education is for students who can't make it." Since school success is measured by standardized test scores in academic subjects and four-year college entrance rates, programs serving work-bound students receive much less attention overall. As a result, vocational programs are not subject to the same accountability as academic programs. Given the the negative aspects of accountability—such as the many ills attributed to standardized testing practices—this may be one of the few examples where the status of vocational education works to the teachers' and programs' benefit.

It is important to note that Ms. Adams's level of autonomy in curricular decisions and student evaluation practices may not constitute the norm. Other classes we visited, namely the aircraft mechanics and computer skills classes, had well-defined domain-specific knowledge and skill requirements. In addition, many vocational courses aim toward preparing students for professional or state-mandated licensing examinations. In these cases, teaching to the test might also be expected.

Teacher Educational Philosophy

Generic skills teaching in these classrooms succeeded, in part, because teachers had strong belief in their importance for workplace success. In addition, teachers' positive attitudes about and high expectations for students and their "student-centered" teaching practices seemed to play a significant role.

Both Ms. Adams and Mr. Smith noted the importance of preparing students for work and "the outside world," and both believed that they taught important skills that were not stressed in the students' other classes. Ms. Adams wanted students to be able to "think for themselves and not take spoon-fed information." She accomplished this by making students responsible for their actions and not accepting their excuses. Talking about first-semester students, she recognized their "lack of depth in design and . . . tried to get them to experiment, find ways to implement ideas, be creative, and value working together." From second-semester students she expected more professionalism, more sophisticated color choices, and well-formed rationales for those choices.

Ms. Adams showed and expressed high regard for her students in several ways. First, she got to know them well enough to be able to treat them as individuals and provide a supportive learning environment.

> EXAMPLE: Joe was a determined and goal-oriented student who preferred to be in control of his environment. He did not relate well to other students. From conversations with him early in the semester, Ms. Adams learned that he had recently overcome peer pressure to join a gang and had decided to stay in school, keep his part-time job, and graduate. When he asked her if he could work alone, she approved his request despite the fact that he was a first-semester student. She told him that he would probably make some mistakes, but she expected him to do his work and present a good final project.

Ms. Adams also took an interest in the students' personal lives and problems.

EXAMPLE: Cara was an abused 17-year-old who had left home and was living on her own. She had an evening job at a local comedy club to support herself. A few weeks into the semester, she stopped coming to class. The other students told Ms. Adams how to reach Cara, and she called to inquire about Cara's plans. Cara had decided to leave school, but Ms. Adams suggested she see a school counselor and consider working toward a GED certificate. A few days later, Cara returned to school, rejoined her classes, made up missed work, and eventually graduated with her class. Ms. Adams showed us a card from Cara, thanking her for the reminder that she "owed herself a chance."

Although Ms. Adams's personal involvement with students may sound either exceptional or extreme, she believed that "there are many issues outside of teaching that are important in the school. I am just amazed at the problems these kids have while they are still taking classes." Although the school had professional (and peer) counseling programs to deal with specific problems, such as drugs, pregnancy, or alcohol abuse, Ms. Adams felt that

> it's important for students to have other ways to get help, otherwise you might miss somebody who doesn't trust a program. I hate to see these kids' lives go down the tubes. If you care about people, you can help them put their lives together.

She was appalled upon hearing a substitute teacher refer to her students as "ninth-grade scum." She rhetorically asked the interviewer, "Are you going to get anything from someone who thinks you're scum?"

Ms. Adams's concern for students was supported by the ROP administrator. In her interview, the administrator defined a good ROP teacher as someone who "has a desire to give some of what they have to students. If the teacher has that desire, the rest falls into place."[10]

Ms. Adams's expectations for students were uniformly high. She demonstrated high expectations, for example, by employing instructional techniques that are not typically used with secondary-school-age students. Other vocational education teachers advised her not to teach nonverbal communication skills to her students because they were too young to learn the material (intended for college age). Ms. Adams went ahead and taught these skills and found that students had no problems learning them. Her work experience had taught her that "you can't put a ceiling on someone's creativity . . . if you do, they'll leave the company." She applied this dictum to her class projects as well: "When I see them reaching, I raise the ceiling quick."

The combination of high respect for students as learners (and as people) and a belief that creativity must be challenged, then, created an atmosphere to support student-centered instruction. Earlier, we outlined several methods and teaching practices that these teachers used to create a learning environment. In addition, their educational philosophy supported a mastery-oriented approach (Dweck and Leggett, 1988) that valued learning over uniform performance and motivated initially uninterested students to successfully complete their class projects.

In these classrooms, teachers and students shared in the process of learning and constructing knowledge. This contrasts with many academic classrooms, where teachers lecture and generally assume a role of imparting knowledge to students, who supposedly have little

[10]Since ROP teachers do not have contracts, the administrator can fire them as she wishes. She recently fired one teacher, for example, who had 30 years of experience in industry but an "old school" approach to students. According to the administrator, he was overly rigid and punitive and had little sensitivity to the ethnic diversity of his students. Thus, although he was technically highly qualified to teach the required domain-specific knowledge and skills, his teaching practices and educational philosophy did not measure up.

knowledge or skill to offer on their own. Student-centered teaching was also highly valued by the ROP administrator. When she evaluated classes, she looked for "interested students doing hands-on work . . . not glassy-eyed bored kids." ROP students were encouraged to come into the office and talk about their classes, thus giving the administrator another view of what was happening there.

Summary of School Context Factors

If we take the position that learning generic skills represents one element of a desirable, high-quality instructional experience, then we have an interest in understanding what aspects of the school context support that instruction. Oakes (1989) identified three context indicators in the research literature: access to knowledge, press for achievement, and professional teaching conditions. These three enabling conditions appear to promote high-quality teaching and learning to the degree that they exist in schools. Thus, they provide one useful way to summarize the information about school context variables obtained from our interviews and observations.

Access to knowledge refers to the extent to which schools provide students with opportunities to learn various domains of knowledge and skills. Several factors seemed to enhance access to knowledge for students in this study. First, Ms. Adams had more funds than other teachers to purchase the necessary materials to support the house design project—the most significant educational activity in her class. While a school's (or teacher's) resource level, in itself, does not guarantee a high-quality educational program, *use* of those resources can make a difference. A second factor affecting access to knowledge is grouping practices. Since this class can be used as a fine arts requirement, it attracts a heterogeneous group with respect to ability and program of study (e.g., academic or vocational). This mix tends to raise the level of teaching and also counteracts negative effects associated with tracking students: individual achievement and aspirations are lower among students in low-ability and nonacademic tracks at the secondary level (Oakes, 1989). Finally, the ROP goal to provide work-related training and its links to the business community expand student access to knowledge through work experience. Students in Ms. Adams's class, for example, have an opportunity to learn through working in a local retail store.

Press for achievement is indicated by institutional pressures that the school exerts to get students to work hard and achieve. Ms. Adams (and Mr. Smith) fostered press for achievement by having high expectations for students and the quality of their work. It is not clear how the school communicates these expectations and values to these students. Our interviews indicate, however, that the school administration may communicate different expectations and values to different types of students: the academic curriculum takes precedence over the vocational, and college enrollment figures are used to measure school success.

Finally, *professional teaching conditions* can empower or constrain teachers and administrators as they attempt to create and implement instructional programs and define how schools function as workplaces for teachers (Oakes, 1989). Ms. Adams faces a mix of conditions. On the positive side, she has little paperwork or bureaucratic requirements, which indicates the primacy of teaching over nonteaching tasks and responsibilities. She has a very supportive ROP administrator at the school. Most importantly, she has autonomy in making classroom curriculum and instructional decisions and flexibility in implementing innovations. These factors are known to support effective teaching (e.g., Purkey and Smith, 1983). On the negative side, Ms. Adams and the ROP sit outside the broader school culture. This isolates her from

colleagues and involvement in schoolwide decisions. Thus she does not engage in school-based activities that can foster learning, such as collaborative staff planning, intellectual sharing, and teamwork. On the other hand, she does participate in staff development activities sponsored by the ROP.

In terms of school context, then, several positive influences on teaching and learning generic skills in this classroom stand out: a supportive ROP administration, a high degree of teacher autonomy, and the teacher's personal educational philosophy. Other school conditions work against access, press, and teaching conditions. Since our view of the school context is limited to the classrooms we visited and the people we interviewed, we do not claim that this picture is entirely accurate. Nonetheless, it is indicative of what this teacher and administrator perceive as the climate around them, and how factors in that climate can enable the desired teaching and learning to take place.

V. CONCLUSIONS AND IMPLICATIONS

The exploratory study reported here investigated the teaching and learning of generic skills in vocational education settings. We define two categories of generic skills: basic or enabling skills and complex reasoning skills. In addition to these skills, which define a person's competency for a task, one must also consider the motivational style or dispositions that influence task performance. Without motivation or positive dispositions, generic skills will be wasted. We further elaborate on complex reasoning skills from the perspective of the human information processing paradigm and apply this conceptualization to identify problem-solving skills in several vocations.

To better understand the teaching of generic skills, we observed several vocational education classes and selected one (a high school interior design class) for intensive study. Three questions guided our fieldwork: What generic skills are taught in vocational classrooms? How are they taught? How does the school context influence instruction?

In response to the first question, the vocational teachers we observed taught several specific problem-solving skills like those defined in our conceptual framework. The teaching of these skills was often embedded in cooperative working arrangements, wherein students worked together to solve "authentic" problems. Teachers also stressed students' acquisition of positive dispositions, such as making independent, bold decisions and taking responsibility for decisions made. Teachers held that acquiring such dispositions was as important as (if not *more* important than) learning particular job-related knowledge or skills.

From the standpoint of traditional academic instruction, these nontraditional course goals led to nontraditional teaching methods. Teachers designed project-centered courses in which students could make many choices (e.g., establish milestones, focus on a single task from an array of tasks) in an environment free from typical classroom rules. Teachers treated students like adults, fostered a climate of mutual respect, and held students accountable for their work using workplace performance criteria. This classroom environment supported teaching of dispositions and, more generally, motivated students in positive ways.

Teachers had several techniques for solving some of the problems that arise in a project-centered classroom where students are given considerable freedom, including techniques for encouraging boldness and independence and for dealing with students who are not proceeding in unison. Overall, lecturing or didactic instruction was minimized, as teachers conducted "micro-apprenticeships" or engaged in one-on-one tutoring. In short, the culture of learning found in these classrooms bears little resemblance to that found in many traditional academic classes.

The interior design teacher found support for carrying out her instructional goals from the ROP program's focus on schooling for work and its close ties with the business community. This teacher seemed to enjoy a great deal of autonomy in deciding how to design and teach the course and evaluate students. However, the reasons for this autonomy remain elusive. On the one hand, it may be due to administrative support or the particular nature of the course we observed. That is, interior design may be less "bound" in terms of domain-specific content than, say, mathematics or other academic subjects, thus giving this teacher more freedom in determining what will be taught. This suggests that fewer domain-specific knowledge and skill requirements permit more leeway for teaching dispositions and workplace attitudes or experimenting with nontraditional instructional practices. On the other hand, the teacher's

autonomy may reflect vocational education's place in the broader comprehensive school environment. This vocational teacher can "get away with" doing things differently because this comprehensive school places more value on academic programs geared to prepare "more qualified" students for higher education. Autonomy, then, may simply be a by-product of neglect.

Regardless of (or perhaps in spite of) vocational education's status, these teachers held high expectations for students and stressed the importance of teaching generic skills and dispositions for the workplace. Their belief in student-centered instruction extended beyond the classroom, as teachers also attended to nonschool issues that concerned students. Educational philosophy and other important personal characteristics of teachers are important ingredients in the teaching we observed.

Below we discuss several conclusions and implications from this analysis with respect to teaching generic skills, educating diverse student populations, and integrating academic and vocational education. This discussion is largely speculative, given the small sample of teachers and the exploratory nature of this research. Strong conclusions or policy implications for teaching and learning generic skills await further research.

TEACHING GENERIC SKILLS

The main contribution of this study toward teaching generic skills has been to isolate and identify some aspects of human problem-solving behavior and to describe how they are taught. In the classrooms we observed, these skills—problem recognition, generation of solution paths, evaluation, repair, and so on—were, for the most part, taught *implicitly* and comprised a relatively small portion of the instructional "package." However, the human information processing model and other cognitive science research on the learning *process* provide several paradigms that seem intuitively applicable to teaching generic skills. For example, this research emphasizes the importance of bringing tacit cognitive processes, like problem recognition and evaluation, into the open where students can observe, enact, and practice them with help from the teacher and other students (Collins, Brown, and Newman, 1989). If Ms. Adams followed this principle in her teaching, she might have simply named the different problem-solving steps in designing the house and discussed how these steps apply to other types of problems as well.

We see the typical lag between theory formulation and its application. Although cognitive science research is certainly influencing the content and method of instruction in some subject areas, its impact on teaching has been minimal overall.[1] The cognitive science perspective has been absent in most research in vocational education (Adelman, 1989), although current efforts have been made to examine its relevance for vocational education reforms (cf. Raizen, 1989). This seems an important priority for cognitive science researchers, who have primarily studied academic subject areas and classrooms. Vocational educators can speed the theory-to-practice transfer by applying known research findings from the cognitive science literature to the development of teaching practices.[2]

The findings from this exploratory study also suggest that elementary and high school students are in need of training to acquire dispositions and attitudes that will serve them well

[1]See, for example, *Curriculum and Evaluation Standards for School Mathematics*, The National Council of Teachers of Mathematics, Reston, Virginia, March 1989.

[2]Ruth Thomas and her colleagues at the University of Minnesota are currently conducting several studies for the National Center for Research in Vocational Education (NCRVE) that focus on the application of cognitive science principles to vocational education.

in the world of work. Vocational (and other) teachers should consider explicitly managing the learning of these skills as well, rather than teaching them "behind the scenes." The vocational teachers in this study had both implicit and explicit ways to teach and model these dispositions, but their methods were guided by their own workplace experience rather than any formal models.

Different types of new research are needed to improve teachers' ability to impart important dispositions and motivate students to learn in the classroom and work effectively on the job. How can teachers help students develop perseverance for difficult tasks, pride in work accomplished, and a desire to be part of a collaborative team? In our study, teachers created a learning environment that supported a "mastery-oriented" response in students (cf. Dweck and Leggett, 1988). However, our study design could not determine which students were already self-motivated and which were changing their behavior in response to the teacher or situation. Further research might measure students' motivational style and track how they respond to motivational contingencies in the learning environment. Other studies might try to manipulate factors that contribute to student motivational styles and see how this affects behavior. An experiment by Dweck, Tenney, and Dienes (cited in Dweck and Leggett, 1988), for example, showed that children's implicit theories of intelligence can be modified to positively affect the goals they choose in a task, but it remains to be seen to what extent this can be done with older students in regular classroom situations. A third study, also suggested by social cognition theory, might determine which situational factors can override or alter existing predispositions to produce more adaptive motivational behaviors that support learning. A teacher might emphasize, for example, that trying a difficult task (showing effort) will count as much as final performance on the task. This might encourage students to adopt a learning goal, provided that their predisposition toward an entity view of intelligence is not too strong (cf. Dweck and Leggett, 1988).

A potentially powerful way to study the interplay of generic skills and dispositions, then, would be to adopt a perspective that combines theory and findings from both cognitive science and social cognition as a way to analyze patterns of cognition-affect-behavior in classrooms or other task-oriented situations.

Our study also indicates that certain contextual factors influence teaching of generic skills. These teachers, for example, had the autonomy to balance the teaching of domain-specific knowledge and skill requirements with generic skills, and to employ nontraditional instructional and evaluation methods. It is difficult to tell how much of what we observed rested on the characteristics of these particular teachers and their educational philosophy. Future research might examine, for example, how much of successful teaching of generic skills relies on teacher experiences and educational philosophy, by studying teachers who differ in these respects. Research should also examine under what conditions teachers have autonomy. Teachers in our study, for example, had autonomy because they were outside the educational mainstream. Policies to "bring them in" might work against that autonomy and actually decrease their ability to innovate.

TEACHING DIVERSE STUDENT POPULATIONS

Recently, much attention has been paid to the increasing diversity of the student population. Immigration, shifting demographics, and other societal and economic factors have contributed to many kinds of changes that schools must address. In California, for example, 209,000 immigrant students (51 percent of the nation's total student immigrant population)

were enrolled in the 1986–87 school year. In the past decade, the number of limited-English-proficient (LEP) students has more than doubled (California State Department of Education, 1988). Ethnic and cultural diversity can strain long-held beliefs about students and schooling and challenge school norms. As one teacher put it, "It's not 'Leave it to Beaver' out there anymore." The local school district has held workshops on diversity, but teachers report that they don't really provide useful methods for coping in the classroom. Ms. Adams believed that, for the most part, teachers in her school are "looking for excellence, for college-bound behavior . . . for high SAT scores. So they give the ESL [English as a second language] kids busywork, don't challenge them, aren't willing to bring discussion down to the students' level of understanding, and aren't willing to compromise."

In our view, one interesting quality of the instructional practice in the vocational classrooms was its appropriateness for teaching a diverse group of students. Ms. Adams's class mixed students out of their academic or vocational "tracks," since it included college-bound students fulfilling a fine arts requirement as well as students hoping to acquire job skills. The class was predominately Anglo, but it included Hispanic, black, Asian, and other minority students. Several were ESL or LEP students.

Several aspects of instruction seemed well-suited to this diverse group. Rather than requiring uniform performance standards, for example, teachers assessed individual student progress. In the case of group work, they also determined a student's contribution to the group. In addition, students had some freedom in their choice of projects or of tasks within projects, which allowed them to tailor their activities to suit their talents or interests. Ms. Adams also formed different groups with an eye toward their diversity. For example, she has formed teams combining English-speaking and ESL students and a team made up exclusively of students with limited English proficiency (two students from Mexico, two from China, and one from Japan).

In addition, the apprenticeship and tutoring aspects of the teaching we observed seemed well suited to student diversity. The apprenticeship model, in particular, has long been associated with vocational education. Traditional apprenticeship methods—coaching, scaffolding, modeling—promote "learning through guided experience," and they are embedded in a social context that supports learning to solve authentic domain problems. Successful apprenticeship activity requires the master to carefully structure the learning environment to support the apprentice's learning; this, in turn, requires careful consideration of the individual student's needs. As described in Sec. IV, these aspects of apprenticeship were quite evident in the vocational classrooms we visited.

Recent research in cognitive science on the *process* of learning has re-examined the traditional apprenticeship approach and proposed the notion of "cognitive apprenticeship" (Collins, Brown, and Newman, 1989). This work goes beyond traditional notions of apprenticeship by making the pedagogy of the apprenticeship approach more explicit for teachers and by extending the traditional model beyond the learning of manual skills.[3] Further research might combine these models of apprenticeship to examine their usefulness for teaching diverse student populations. Questions for further research include: How can apprenticeships be structured to serve diverse students in a large classroom setting? Can apprenticeship techniques be applied to teaching domain-specific knowledge and skills and *generic* skills, in addition to complex

[3]The basic notion is to apply apprenticeship methods (including the social context and authentic problem characteristics) to the teaching and learning of domain-specific subjects, such as mathematics and reading. In testing this notion, Collins, Brown, and Newman have specified several characteristics of ideal learning environments, including types and sequencing of knowledge, teaching methods, and social arrangements.

physical processes and skills? What kinds of skills do teachers (vocational or otherwise) or students need to play the "master" role in apprenticeship arrangements?

INTEGRATING ACADEMIC AND VOCATIONAL EDUCATION

Finally, our research led us to speculate about recent reforms calling for the integration of academic and vocational education as one way to restructure education to better meet the needs of all students. In the spirit of reform, both vocational and academic educators search for ways to integrate curriculum, but from somewhat different perspectives. Vocational educators have responded to recent legislation and external criticism by developing and implementing new courses and programs (cf. Grubb et al., 1990; Adelman, 1989). Many of these have the flavor of making vocational education "more academic." The California Peninsula Academies model, for example, combines the core academic curriculum with technical instruction in a particular occupational field (cf. Stern et al., 1988). Other solutions go beyond teaching the basic three Rs to encompass a broader range of skills, such as thinking and problem solving (e.g., Adelman, 1989).

Academic school reformers, on the other hand, have been motivated by the poor performance of schoolchildren and advances in cognitive science research to make academic learning more meaningful for all students and, at the same time, better prepare all students for the world of work. Although the term "integration" is not typically applied to reforms in academic education practice, new curriculum and theoretical approaches have the flavor of making academic instruction "more vocational." Models of cognitive apprenticeship (discussed above), for example, draw heavily from studies of traditional vocational apprenticeship training (e.g., Lave, 1977) and recommend "situating" learning in contexts that reflect how a skill will actually be used (e.g., Collins, Brown, and Newman, 1989).

In short, both academic and vocational educators have much to contribute to the design of integrated educational practice. One aspect of curriculum reform common to both is the need to improve students' abilities to reason, think, and solve problems. That is, both see "generic skills" as important learning skills for students "in school and out"—from school to the workplace or throughout one's life.

If this is one goal of integration, then we might envision a model of integration based on teaching generic skills and dispositions to all students in both academic and vocational classrooms. While the present study represents a first step in articulating that model, more research is clearly needed. Future research should analyze the acquisition and teaching of target generic skills and dispositions in both vocational and academic classrooms. Several important questions remain with respect to teaching these skills, particularly in academic settings. The vocational teachers' approach was to teach generic skills in the context of an "authentic" problem, carried out cooperatively by a team of students. In addition, teachers structured the classroom rules and expectations to resemble, as much as possible, an actual working environment. It is not clear to what extent these features of instruction depend on the subject area. For example, it is possible that this approach, and other specific teaching practices used in interior design (e.g., micro-apprenticeship and tutoring instead of lecturing), may not generalize well to mathematics or English instruction.

Another issue concerns the importance of workplace experience for teaching some important dispositions or for executing some instructional approaches. The teachers in this study had real-life experience in the "culture of practice" that provides knowledge and understandings valued by practitioners. This form of expertise is just as important as skill in performing

tasks and solving problems in the workplace. It is part of what constitutes the practice of expert work, as well as what the expert (or master craftsman) imparts to the novice (or apprentice). Thus, the expert can teach or model both skills and attitudes. It is not clear to what extent the culture of practice is developed through real work experience. Furthermore, it is hard to imagine the analog to the culture of practice in an academic domain, although some argue that good mathematics instruction includes an understanding of how mathematics is done by mathematicians—the culture of the "mathematician" (e.g., Schoenfeld, 1987). It is possible that some lessons for successfully adapting to the workplace "culture of practice"—such as taking responsibility for one's own behavior or making independent decisions—are more easily incorporated into teaching in vocational than in academic classrooms.

As a final recommendation, future research to develop a model of teaching generic skills for all students—or to address other questions presented in this section—should analyze the acquisition and teaching of target skills at a level that will inform curriculum development and teacher training. Broad descriptions of needed workplace skills are not enough. Since teachers have the ultimate responsibility for carrying out any curricular reforms, research must aim to inform teachers' practice.

Appendix

SUMMARY OF SELECTED LITERATURE

To identify the scope and content of previous research on "generic skills," we searched the cognitive science, vocational education, training, and workplace literatures. We summarize some findings from these sources in Sec. II. We discovered that not only was terminology diverse, the types of items included under this "generic" umbrella varied greatly. For example, the lists of generic skills were labelled "generalizable skills," "attributes," "talents," "transferable skills," and "occupational adaptability skills." Moreover, the content within lists included basic skills (i.e., math, reading, writing), thinking and problem-solving skills, attitudes and dispositions, creativity, and physical attributes.

This appendix displays the results of this search as a referenced list of workplace skills considered domain general, plus a notation identifying the setting involved (secondary, postsecondary, workplace, etc.) and the sample (teachers, administrators, adult workers, etc.). Greenan's (1984) entry includes sources that he cites in his review.

"Generic Skill"	Setting	Sample	Reference
Transferable Skills: Communication Working with others Problem solving Analyzing/assessing Planning/layout Organizing Managing others Decision making Positive work attitudes	Workplace	Educators, personnel officers, trainers	Wiant, 1977
Basic skills conceptualized as "generalizable" skills: Mathematics Communications Interpersonal relations Reasoning	Public secondary voc ed/ postsecondary voc ed	Teachers	Greenan, 1983
Aptitude in verbal comprehension, arithmetic reasoning, manual dexterity Interest/temperament	Workplace	—	Greenan, 1984 (cites Mecham and McCormick, 1969)
Attributes: Ideation fluency Originality Problem sensitivity Spatial orientation Reflective attention Time sharing Stamina Speed of limb movement	Workplace	—	Greenan, 1984 (cites Marquardt and McCormick, 1972)
Work elements: activities/conditions Work attributes: abilities/personality traits	Workplace	—	Greenan, 1984 (cites Cunningham, 1971)
Talents: Creative or productive thinking Evaluative or decision-making talent Planning Forecasting Communication	Workplace	—	Greenan, 1984 (cites Taylor, 1973)
Transferable skills: Intelligence Aptitude Interpersonal Attitudinal	Workplace	Conference participants	Greenan, 1984 (cites Wiant, 1977)
Listening Speaking Verbal communication Job-related competencies Writing	Trade/ industrial occupations	Community college/ technical institutes' administrators, vocational teachers, English teachers	Greenan, 1984 (cites Howell, 1977)

"Generic Skill"	Setting	Sample	Reference
Legible handwriting Accurate, fast arithmetic calculation Spell common nouns Familiar with job names Understand/interpret info presented by phone alone Communicate an attitude of interest/ helpfulness Perform simultaneous tasks Flexibility in changing work strategies under various supervisory/reward conditions Apply rules to new examples Apply multiple procedural rules in a classification task Listening and talking Construct learning/job aids to guide learning and performance	Workplace (broad range of occupations)	—	Greenan, 1984 (cites Short, Dotts, Short, and Bradley, 1974)
Adult literacy skills: Communication (read, write, speak, listen) Computational skills Problem-solving skills Interpersonal skills	Workplace	Adult	Greenan, 1984 (cites Northcutt, 1975)
To transfer skills to job: Task performance skills Skills to apply broad usable knowledge Personal/interpersonal effective skills Self-analysis skills Career management and productivity To apply broadly usable knowledge: Able to know where and how to access information Commit knowledge to memory Recall information accurately Identify information needed for occupational tasks Use knowledge in decision making and problem soiving Create new knowledge as result of synthesizing existing knowledge	Workplace	Training/ guidance programs focused on transferable occupational skills	Greenan, 1984 (cites Miguel, 1977)
Occupational survival skills: Working in organizations Understanding self Motivation for work Interpersonal relations Effective communication Using creativity at work Coping with conflict Coping with change Adapting and planning for the future	Vocational/ career education programs	Workers, students, parents, teachers, counselors, administrators	Greenan, 1984 (cites Nelson, 1979)

"Generic Skill"	Setting	Sample	Reference
Work adaptation skills (or "aspects"): Organizational Performance Interpersonal Responsibility Affective	Workplace	—	Greenan, 1984 (cites Ashley, Cellini, Faddio, Pearlson, Wiant, and Wright, 1980)
Consumer economic skills: Consumer power Money management Consumer finance Occupational adaptability skills: Good work attitude Manage one's own time and activity	—	General adult population	Greenan, 1984 (cites Selz, 1980; Selz and Coleman, 1980; Selz, Jones, and Ashley, 1980)
Group problem-solving skills: Interpersonal Group process Problem solving Decision making Planning Communication Thinking/reasoning Organization and management skills: Business economics Business operations Management Statistical quality control Introduction to "quality of work life"	Workplace/ high-involvement, participative work settings	Firms with known QWL reputation	Pratzer and Russell, 1984
QWL activities: Teamwork Cooperative diagnosis Cooperative problem solving (interpersonal relations/group process, communication, thinking, reasoning) Dealing with ambiguity and uncertainty Managing difference Making informed judgments about multiple outcomes and realities	Workplace	Firms with known QWL reputation	Pratzer and Russell, 1984
Thinking skills: "Use their heads at work" Acquire information Communicate Teamwork Active inquiry	Public secondary schools	—	Stern, Hoachlander, Choy, and Benson, 1985
Critical thinking skills: Recognition that a problem exists Definition of real-world, ill-structured problems Identify limited information and seek requisite information Understand that solution depends on context Define goals in ill-defined situations Group problem-solving skills	—	—	Sternberg, 1985

"Generic Skill"	Setting	Sample	Reference
Handle unpredictable and nonroutine problems and circumstances Experience how generic principles and processes translate into specific work Values and attitudes regarding work: Cooperative working relationships Commitment to quality Social responsibility in creation and distribution of goods	Public secondary schools	—	Oakes, 1986
Participate in socially shared intellectual work Listen to and analyze arguments Gather information and know how to use it Reason, analysis, and reflection	—	—	Resnick, 1987b
Problem solving Knowledge acquisition Self-management	Secondary voc ed	—	Chipman, 1988
Troubleshooting Problem solving Communication Interoperability Motivation	—	Military	Garretson, 1988
Systematic and abstract knowledge Understand multiple arrays of info and rules governing them Understand relationships between arrays Frame answers to less standardized requests	Workplace	Claims adjusters	Shanker, 1988
Need to be adaptable to profit from changing workplace: Set goals and develop/implement strategies to achieve them Know how to learn new information and skills Use info contained in context and apply it to another Identify where and from whom to access information Solve problems Function as members of multiple work teams	Michigan workplace	Operations and human resource executives	Michigan Employability Skills Task Force, 1988
Skills for the modern workplace Initiative Cooperation Working in groups Peer training Evaluation Communication Reasoning Problem solving Decision making Obtaining and using information Planning Learning skills Multicultural skills	—	—	Raizen, 1989 (cites Levin, 1988)

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